



US Army Corps
of Engineers
New England Division

Drought Contingency Plan

SEPTEMBER 1993

Hop Brook Lake, Connecticut



SUMMARY

Drought contingency storage is not implementable at Hop Brook Lake because of ongoing and potential water quality problems. Due to these recurring problems, many studies have been conducted to identify coliform and nutrient sources, and to determine the cause of excessive algal growth. Measures have been started in an attempt to improve the water quality at Hop Brook Lake. However, since these problems still exist, and would be exacerbated if drought storage operations were implemented (see appendix C for complete evaluation), drought contingency storage is not recommended at this time.

Since the drought contingency plan was nearing completion at the time of the recommendation, the comprehensive plan is presented herein for informational purposes only. If the water quality situation improves in the future, drought contingency storage will be re-evaluated and this report supplemented as necessary to respond to the situation.

DROUGHT CONTINGENCY STORAGE FOR EMERGENCY WATER SUPPLY
PURPOSES AT HOP BROOK LAKE IS NOT IMPLEMENTABLE

DROUGHT CONTINGENCY PLAN
HOP BROOK LAKE

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DROUGHT CONTINGENCY PLAN
HOP BROOK LAKE

1. PURPOSE AND SCOPE

The purpose of this study and report was to develop and set forth an emergency drought contingency storage plan for operation of Hop Brook Lake that would identify how the New England Division could render assistance to the State of Connecticut during State declared drought emergencies affecting domestic, municipal and industrial water supplies. The scope of this report was not to address the feasibility of providing a permanent water supply pool at Hop Brook Lake, but rather to address the use of a temporary short term pool during a drought emergency. Assistance would be provided through flexibility of regulation and use of existing storage at Hop Brook Lake. However, as mentioned in the summary, Hop Brook Lake will not be used for drought contingency storage because of existing water quality problems; therefore, this plan is not implementable at this time. Included are descriptions of present operating regulations, existing water supply conditions, plan for utilization of short term emergency storage during a drought, a water quality evaluation, drought storage/releases cost, impacts on other project purposes, identification of a State sponsor, and a conclusion.

2. AUTHORIZATION

Authority for drought contingency plans is contained in ER 1110-2-1941, dated 15 September 1981, which provides that water control managers continually review and when appropriate, adjust water control plans in response to changing public needs. Drought contingency plans will be developed on a regional, basin-wide or project basis as an integral part of water control management activities and in accordance with an approved water control plan.

3. PROJECT AUTHORIZATION CONDITIONS

Hop Brook Lake was authorized by the Flood Control Act approved 14 July 1960, Public Law 86-645, 86th Congress, 2d session substantially in accordance with the recommendations of the Chief of Engineers in House Document 372. This lake has been authorized as a flood control project which includes a permanent conservation pool. Authorization for development and use of the lake area for public recreation and other purposes is contained in section 4 of the Flood Control Act approved 22 December 1944, as amended.

4. PROJECT DESCRIPTION

Hop Brook Lake, completed in 1968, is a dual purpose flood control and recreation project, located on Hop Brook, in the towns of Waterbury, Naugatuck and Middlebury, Connecticut. A map of the Housatonic River basin is shown on plate 1, with a map of the Naugatuck River watershed shown on plate 2.

The project contains storage for flood control and recreation. The 18-foot deep recreation pool (elev. 310 feet NGVD) contains 120 acre feet equal to 0.12 inch of runoff. The flood control storage contains 6,850 acre-feet which equals 7.8 inches of runoff from the 16.4 square miles of drainage area. A capacity table is shown on plate 3, and a summary of pertinent data at Hop Brook Lake is listed on plate 4.

The physical components of the Hop Brook project consist of a rolled earthfill and rock-faced dam, outlet works, a chute spillway, and a small recreation pool. The outlet works, located along the left bank, consist of an intake channel, a concrete weir to maintain the permanent recreation pool, a control tower, a 425-foot long, 3 foot wide by 4 foot high rectangular conduit, a stilling basin and an outlet channel. The discharge through the conduit is controlled by two 3 x 4-foot slide gates, with an intake channel weir located upstream of gate 1. The six stoplog openings of the control weir are 4 feet deep for flexibility in maintaining the level of the permanent pool.

5. PRESENT OPERATING REGULATIONS

a. Normal Periods. The recreation pool is approximately 18 feet deep and is maintained by a concrete weir and stoplog structure upstream of gate 1. During the freezing season, gate 1, the exposed flood control gate, is operated daily to prevent freezing.

b. Flood Periods. Hop Brook is operated in concert with other projects in the Naugatuck River basin to reduce downstream flooding along the Naugatuck and Housatonic Rivers. Operations for floods may be considered in three phases: Phase I - appraisal of storm and river conditions during development of a flood, phase II - flow regulation and storage of flood runoff at the reservoir, and phase III - emptying the reservoir during recession of the flood. The regulation procedures are detailed in the Master Water Control Manual for the Housatonic River Basin. A minimum release of 10 to 20 cfs (6.6 to 13 mgd) is maintained during periods of flood regulation in order to sustain downstream fish life. The

maximum nondamaging discharge immediately downstream of Hop Brook Lake is approximately 550 cfs.

c. Monitoring. The Reservoir Control Center directs reservoir regulation activities at 28 manned New England Division flood control dams and continually monitors rainfall, snow cover, and runoff conditions throughout the region. When any of these hydrologic parameters have been observed to be well below normal for several months and it appears that possible drought conditions might be developing, the Corps Emergency Operations Center (EOC) will be informed. The EOC will then initiate discussions with the respective Federal and State agencies and other in-house Corps elements to review possible drought concerns and future Corps actions.

6. DESCRIPTION OF EXISTING WATER SUPPLY CONDITIONS

a. General. The area of concern are those communities in southwestern Connecticut in the vicinity of Hop Brook Lake. These communities encompass portions of Fairfield, Hartford, Litchfield, and New Haven Counties. Table 1 contains information about public water suppliers in the area which have a service population greater than 1,000. Data presented for the major water suppliers include towns served, estimated service population, actual water production for calendar 1980 or 1981, and the safe yield for active water supply sources. The table has been formulated using data primarily provided by the State of Connecticut Department of Environmental Protection, supplemented with information from the Housatonic River Basin Urban Study, published by the Corps of Engineers in September 1982. In those instances where data provided by the State was incomplete, information from the Corps Housatonic River Basin Study was used. Any remaining missing information was not developed as such efforts were considered beyond the level of detail required for this study.

b. Water Supply Systems. The primary objective of this analysis was to accumulate available data regarding water supply systems in the vicinity of Hop Brook Lake that could benefit from storage at the project, and to present the data in a manner portraying existing water supply conditions. Projections of future demands were not developed because this study addresses only modifications in the operational procedures at Hop Brook Lake in order to provide storage for water supply purposes when drought conditions exist, and not to meet normal water supply demands at some future date.

c. Southwestern Connecticut Water Supply. Information pertaining to the larger water suppliers in the vicinity of Hop Brook Lake in southwestern Connecticut are presented in

table 1. An analysis as to whether existing sources can provide adequate supplies during drought conditions was not performed. The information has been accumulated to present a summary of the existing water supply conditions pertaining to major water suppliers in southwestern Connecticut.

d. Population Projections. Population projections for communities in the study area are given in table 2 to show population trends for each community potentially affected by a prolonged dry period. The projections were taken from Population Projections for Connecticut Municipalities and Regions to the Year 2000, published by the State of Connecticut Office of Policy and Management. This information is presented to indicate potential future growth in southwestern Connecticut.

7. SPONSOR

a. General. In an effort to make the Drought Contingency Plans fully implementable, it is required to identify a local sponsor. If a local sponsor cannot be found, then the plan will be considered inactive and drought storage at the Corps Reservoir will not be studied further. The approach is for a State to enter into a contract with the Secretary of the Army (or his representative) and agree to act as wholesaler for all water requirements of individual users. This places local governments in a position to help their citizens during difficult times and minimize potential problems that could arise if the Secretary of the Army were to determine who was entitled to shares of drought emergency water, based on assessments of local needs. The sponsor is required to express an interest in utilizing short term storage at the Corps reservoir for emergency water supply and/or other instream flow requirements. By expressing interest, the sponsor will be required to enter into an emergency water supply contract specifying the potential water supply available and costs associated with emergency water supply releases from the Corps project.

b. Hop Brook Sponsor. The State of Connecticut, Department of Health Services (DOHS) was identified as the lead Agency most likely to act as sponsor for the Hop Brook Drought Contingency Plan, but, as the project became non implementable, no confirmation letter of this was pursued. A copy of a Draft Emergency Drought Contingency Water Supply Contract, is presented in appendix D.

During discussions with DOHS it was determined that the primary users of drought storage at Hop Brook Lake would most likely be the Connecticut Water Company. There is a possibility of the diversion of water from the existing Hop

TABLE 1
SOUTHWESTERN CONNECTICUT - MAJOR WATER SUPPLIERS

Company	Towns Served	Estimated Population Served	Source of Supply GW/SW	Year	Water Production		Average Daily Demand (MGD)	Safe Yield Active Sources	
					Surface (MG)	Ground (MG)		SW (MGD)	GW (MGD)
Ansonia-Derby Water Co.	Ansonia Derby	20,500 11,500	GW/SW	1981	995.9	808.5	4.94	3.10	10.70
Bridgeport Hydraulic Co.	Beacon Falls Monroe Seymour Shelton	1,834 4,311 8,496 22,860	GW/SW	1981	6,872.0	3,297.8	27.86 ²	7.40	26.58
Fairfield Hills Hospital	Newtown	3,200	GW	1981		127.1	0.35		1.84
Heritage Village Water Co.	Middlebury Oxford Southbury	25 50 5,500	GW	1980		63.3	0.17		.90
Indian Hill WC, Ind. Field Co.	Naugatuck	1,389	GW	1980		352.7	0.97		.35
Naugatuck Div., Conn. Water Co.	Beacon Falls Naugatuck Waterbury	200 18,851 315	GW/SW	1980	1,163.8	49.5	3.32	4.77	-
Newtown Water Co.	Newtown	3,200	GW	1981		120.3	0.33		-
Plainville Water Co.	Bristol Plainville Southington	45 16,351 485	GW	1980		905.7	2.48		2.95
Southbury Training School	Southbury	2,450	GW	1980		118.6 ¹	0.32		0.66
South Central Conn. Regional Water Auth.	Cheshire	17,800	GW/SW	1981	-	632.6	-	-	3.36
Southington Water Works Dept.	Cheshire	248	GW/SW	1980	278.7	995.6	3.49	-	3.03
Terryville Div., Conn. Water Co.	Plymouth	5,642	GW/SW	1980	5.9	155.6	0.44	-	0.74
Thomaston Div., Conn. Water Co.	Thomaston	2,831	GW/SW	1980	110.1	71.8	0.50	0.40	0.11
Waterbury Water Bureau	Waterbury	103,300	SW	1980	7,823.0		21.43	70.50	
Watertown Fire Dist.	Watertown	6,600	GW/SW	1980	0.0	301.5	0.83	1.39	12.80
Woodbury Water Co.	Woodbury	1,700	GW	1980		59.6	0.16		0.11

¹Information taken from Housatonic River Basin Urban Study, U.S. Army Corps of Engineers, September 1982. All other information provided by the State of Connecticut, Department of Environmental Protection, Natural Resources Center.

²Demand determined by withdrawals from supply sources in study area communities. A large portion of this demand actually occurs in communities outside the study area.

TABLE 2

POPULATION PROJECTIONS
COMMUNITIES NEAR HOP BOOK LAKE

<u>Town</u>	<u>Actual 1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>	<u>Percent Change 1980-2000</u>
Ansonia	19,039	19,210	19,260	19,270	19,220	1.0
Beacon Falls	3,995	4,150	4,250	4,350	4,400	10.1
Bethany	4,330	4,480	4,630	4,780	4,900	13.2
Bethlehem	2,573	2,710	2,850	2,980	3,120	21.3
Cheshire	21,788	23,290	24,790	25,790	26,790	23.0
Derby	12,346	12,540	12,810	13,010	13,110	6.2
Middlebury	5,995	6,080	6,200	6,310	6,380	6.4
Monroe	14,010	14,920	15,980	16,950	17,610	25.7
Naugatuck	26,456	27,150	28,040	28,900	29,640	12.0
Oxford	6,634	7,210	7,680	8,140	8,540	28.7
Plymouth	10,732	11,080	11,380	11,600	11,730	9.3
Prospect	6,807	6,790	6,810	6,760	6,630	-2.6
Seymour	13,434	14,270	15,340	16,540	17,640	31.3
Shelton	31,314	32,770	34,320	35,600	36,300	15.9
Southbury	14,156	15,060	15,760	16,460	17,260	22.6
Southington	36,879	37,880	39,380	40,580	41,580	12.8
Thomaston	6,276	6,390	6,570	6,730	6,780	8.0
Waterbury	103,266	102,760	103,660	104,530	105,410	2.1
Watertown	19,489	19,790	20,090	20,390	20,690	6.2
Walcott	13,008	13,220	13,650	13,940	13,990	7.6
Woodbridge	7,761	7,860	7,960	8,060	8,110	4.5
Woodbury	<u>6,942</u>	<u>7,110</u>	<u>7,220</u>	<u>7,280</u>	<u>7,260</u>	<u>4.6</u>
TOTAL	387,230	396,630	408,630	418,950	427,090	10.3

Brook Lake drought pool to the Meshaddock Brook reservoir, located in the vicinity of Hop Brook off Nichol Street in Naugatuck. Meshaddock Brook reservoir is a tributary of Hop Brook.

c. State and Local Contingency Planning. In the event of a water supply emergency declaration in the area of Hop Brook Lake by the Governor or otherwise according to law, the State of Connecticut would initiate a set of procedures in order to ensure a constant supply of water to the potential users in the Naugatuck Region of Connecticut. Guidance for these procedures is provided in the Water Companies Planning Guidance for Emergency Contingency Plans (December 1990) prepared by the Departments of Environmental Protection (DEP), Health Services (DOHS) and Public Utility Control (DPUC) and the Offices of Consumer Counsel and Policy Management. These regulations require water companies supplying water to one thousand or more persons, or 250 or more consumers, to prepare a water supply plan. One component of the plan is "contingency procedures for public drinking water supply emergencies including emergencies concerning the contamination of water." The Connecticut Water Company is the most likely beneficiary of emergency storage at Hop Brook Lake and has prepared an Emergency Contingency Plan (see appendix D) which presents the following steps of water shortage severity.

1. Alert
2. Advisory
3. Emergency - Phase I
4. Emergency - Phase II
5. Emergency - Phase III

Emergency Phase I would be activated by a declaration of water supply emergency and coincides with Phase II - Drought Emergency described below in paragraph 8e(2).

The potential users have the opportunity to notify the sponsor of slower developing water shortages triggered by low rainfall.

8. PROPOSED ASSISTANCE PLAN

a. General. There are several authorities providing use of reservoir storage for water supply at Corps of Engineers projects. These vary from provisions of water supply storage as a major purpose in new projects to the discretionary authority to provide emergency supplies to local communities in need. Under authority of ER 1110-2-1941 New England Division is directed to determine the short term water supply capability of their existing reservoirs that would be

functional under existing authorities. Congressional authorization is not required to add municipal and industrial water supply if the related revisions in regulation would not significantly affect operation of the project for the originally authorized purposes.

b. Hop Brook Plan

(1) There is no storage allocated for water supply at Hop Brook Lake; therefore, the only existing drought assistance capability would be through increased flexibility of regulation and short term use of project authorized storage. We determined that the Hop Brook pool can be raised to elevation 312.0 feet NGVD to provide short term drought emergency assistance without compromising the flood control purpose of the project nor negatively impacting the recreational aspects of the project. A pool of 312.0 feet NGVD, represents a volume of about 46 acre-feet (15 million gallons) over the conservation pool.

(2) The extent of Corps assistance is limited to the time of year drought conditions exist, as well as availability of sufficient inflow to the reservoir. Anticipating that there would be sufficient inflow as well as enough forewarning to fill the reservoir in the May to June timeframe, the Corps should be in a position to render assistance during the preceding historic low flow summer months (July to October timeframe). Based on the May to June low flow duration analysis, it was determined that during a 10-year frequency drought there would be sufficient riverflow to fill the reservoir from the recreation pool to the drought pool in about a 16-day period. During this filling period, a minimum release rate from the dam of about 3.5 cfs (7Q10 low flow for the May to June timeframe, see plate 5) or inflow, whichever is less, would be maintained whenever possible. However, if there is insufficient inflow available or if conditions exist within the watershed that would prevent the Corps from storing water to the drought pool level, the amount of assistance from the Corps may be limited.

(3) Once the water was stored at the drought pool level and a "declared" drought emergency existed, a water supply contract would be signed by the Corps and the State of Connecticut and emergency water supply releases would be made from the project. We anticipate that these releases and or diversions would be in addition to passing all inflow through the dam and would occur during the July to October timeframe and continue until the pool level was lowered to the conservation pool. At that time New England Division would decide whether any additional water supply releases would be allowed to drawdown an increment of the conservation pool.

(4) If assistance is requested beyond the May to June timeframe, the period to fill as well as the risk associated with flood protection would have to be decided by New England Division prior to initiation of the drought storage operation. We assume that some variation of the drought procedure mentioned above would be possible to render assistance regardless of the time of year. Minimum release rates (generally equal to the seasonal 7Q10), as well as drought pool filling durations would vary, depending on the season of the year when assistance is needed. Drought contingency storage versus flow duration at Hop Brook Lake are shown graphically on plate 5.

c. Water Shortage Indicators. The Reservoir Control Center (RCC) of the New England Division will keep abreast of current hydrologic as well as climatologic data at all Corps projects in an effort to aid in recognition of the onset of dry or drought conditions. A series of guide curves have been developed as a tool in this recognition process. Curves such as rainfall-duration-frequency and minimum-surface runoff-frequency were developed for various index stations throughout New England. Index stations were selected based on proximity to Corps reservoirs, period of record, and reliability of data. The guide curves were developed and compared with historic drought data as a way to "track" current observed conditions with comparable historic conditions. Appendix A presents the guide curves with an explanation on their development and use. Also presented in appendix A is the Palmer Drought Severity Index (PDSI) classification chart with available New England historic index levels.

As data is monitored by RCC, it will be used with these guide curves as well as supplemental information received from various Federal and State Agencies prior to decisions of storing emergency drought water at Hop Brook Lake.

d. Emergency Operations Center. As RCC collects and monitors climatologic and hydrologic data associated with dry or drought conditions, the New England Division EOC will initiate discussions with in-house Corps elements as well as other respective Federal and State Agencies to review possible drought concerns and for Corps action. For Hop Brook Lake coordination, the lead State Agency is:

Department of Health Services
Water Supplies Section
150 Washington Avenue
Hartford, Connecticut 06106
Telephone 203-566-1253

All decisions regarding Corps action during dry or drought conditions will be made through the EOC.

e. Phases of Drought Assistance. Drought assistance from Hop Brook Lake will be in two phases. Phase I will be during "drought watch" conditions existing within the Hop Brook region of Connecticut and Phase II - drought emergency declared by the State of Connecticut. Phases I and II are explained below.

(1) Phase I - Drought Watch. This is the initial phase of implementation of drought assistance. The following conditions and actions will take place during this phase:

(a) Initial indications conclude that a drought condition is developing within this region of Connecticut. Close coordination between New England Division and other Federal and State agencies, in addition to coordinated efforts within the EOC, have identified that a drought condition is beginning (refer to appendix A for climatologic and hydrologic guide curves of precipitation as well as surface runoff data). This coordination will insure that actions being taken, as well as all decisions, are targeted to meet specific needs and not to react prematurely.

(b) Pending coordination with the Connecticut Department of Health Services and their subsequent concurrence with the Corps to store water at Hop Brook Lake, and subject to availability of inflow, Hop Brook reservoir will be filled to elevation 312.0 feet NGVD.

(c) The water will be stored at this level and outflow will be set equal to inflow in order to maintain the pool at a constant level. This pool will be maintained until the Connecticut Department of Health Services formerly requests emergency water supply releases be made. This will take place during the drought emergency phase. Release rates would then be equivalent to inflow plus water supply demand (as requested by DOHS).

(2) Phase II - Drought Emergency

(a) A drought emergency declaration has been declared by the Governor of Connecticut, or otherwise according to law, and issued by the Connecticut Department of Health Services.

(b) Department of Health Services contacts New England Division, requesting that releases of a specific amount, be made.

(c) Emergency Operations Center convenes a meeting with the Division Engineer and other in-house Corps elements to discuss request.

(d) If emergency water supply releases are to be made, a target release rate will be determined by New England Division. This rate will include the natural inflow to the reservoir as well as the water supply release rate requested by DOHS. Prior to any releases, the water supply contract will be signed by the Corps and the State of Connecticut.

(e) Drawdown of the pool will continue until lowered to the conservation level. At that time New England Division will decide whether any additional water supply releases would be allowed to drawdown an increment of the conservation pool (during this operation any recovery of water supply storage will be made if conditions permit).

f. Compensation for Use of Storage. As directed in ER 1105-2-100 dated 28 December 1990, compensation must be received for all "emergency drought releases." This compensation will be at least equal to a proper share of annual joint use O&M costs and major replacement expenses plus revenues foregone as well as other costs directly attributable to making releases. For Hop Brook, an approximate annual cost of \$2,649 has been determined for the release of approximately 46 acre-feet of drought assistance water based on 1993 dollars. Appendix B presents the Economic Assessment of Drought Contingency Water Supply Pricing at Hop Brook. Said costs are also identified in the draft water supply contract in appendix D.

9. DISCUSSION OF IMPACTS

a. General

(1) Any action resulting in a temporary change of reservoir storage volumes will have impacts on authorized project purposes, which must be evaluated as part of the drought storage implementation plan. At Hop Brook Lake, the drought contingency plan is one component of the existing, approved total water control plan. Presented below is a cursory evaluation of impacts resulting from drought contingency storage on flood control and recreation purposes of the project.

(2) An Environmental Assessment (EA) was prepared in 1977 to evaluate the Operation and Maintenance aspects of the subject project, however, this document does not address the environmental impacts related to the drought contingency plan. Therefore, prior to implementation of drought

contingency storage, an Environmental Assessment would be prepared in accordance with the National Environmental Policy Act (NEPA) of 1969. The new assessment would address impacts to water quality, wetlands, aquatic habitats, terrestrial habitats and historic/archaeological resources resulting from storage of water during a drought emergency. In addition, the assessment would comply with Federal, State and local environmental regulations and will be coordinated with appropriate Federal and State agencies.

(3) The Corps of Engineers routinely updates all Environmental Assessments associated with Operation and Maintenance of Corps projects in New England. These newly updated documents address the impacts of the current water control plan, including drought contingency storage. Should a drought emergency occur prior to completion of this document, the Corps of Engineers is still responsible for complying with NEPA prior to implementation of drought contingency storage.

b. Flood Control. A review of regulation procedures at Hop Brook Lake was undertaken to determine the volume of water that could be made available for emergency drought contingency purposes. The water would be stored by temporarily utilizing existing flood control storage. We recognize that major floods occur in every season of the year and any use of flood control storage would be continually monitored to insure there would be no adverse impacts on downstream flood protection.

At Hop Brook Lake, the maximum pool elevation for drought contingency storage has been estimated to be 312.0 feet NGVD, representing an infringement on flood control storage of about 0.06 inch, from the total storage capacity of 7.8 inches of runoff, from the 16.4 square mile upstream drainage area. At an elevation of approximately 312.0 feet NGVD, water can be stored without significantly affecting flood control capability or other regulation activities.

c. Water Quality. The proposed drought contingency storage at Hop Brook Lake would raise the pool 2.0 feet above its current elevation of 310.0 to 312.0 feet NGVD, and from a maximum depth of 30 to 32 feet. This increase would only occur during a declared drought period. Changes in lake water quality caused by droughts include reduced dissolved oxygen levels and increases in water temperature, iron, manganese, ammonia, phosphorus, and color. These increases could be significant and lead to a major degradation in aquatic habitat, depending on the severity of the drought. The lake would also be subject to a greater potential for the occurrence of severe algae blooms, especially since considerable algae problems already exist at this

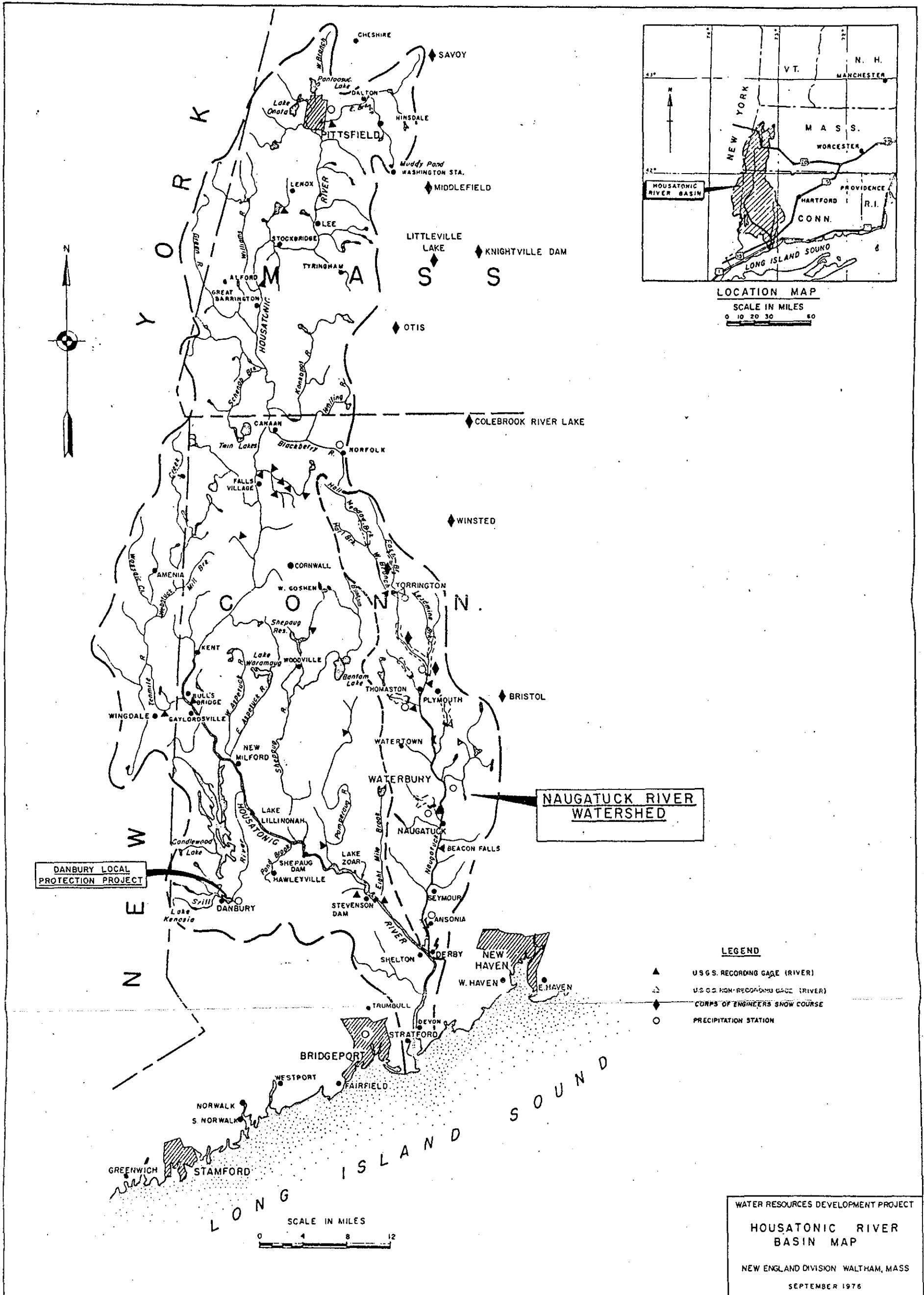
project. Increasing the pool size for drought storage, would further increase the nutrients and potential for algae problems. The lake is heavily used for recreation including swimming, but has to be closed some times because of water quality problems. Increasing the size of the pool would increase water quality problems, which would cause more frequent closing of the lake for recreation. Additionally, increases in suspended solids, iron, and color would be expected in downstream discharges. For these reasons, drought contingency storage is not recommended at Hop Brook Lake. Appendix C presents a comprehensive water quality evaluation regarding drought contingency storage at Hop Brook Lake.

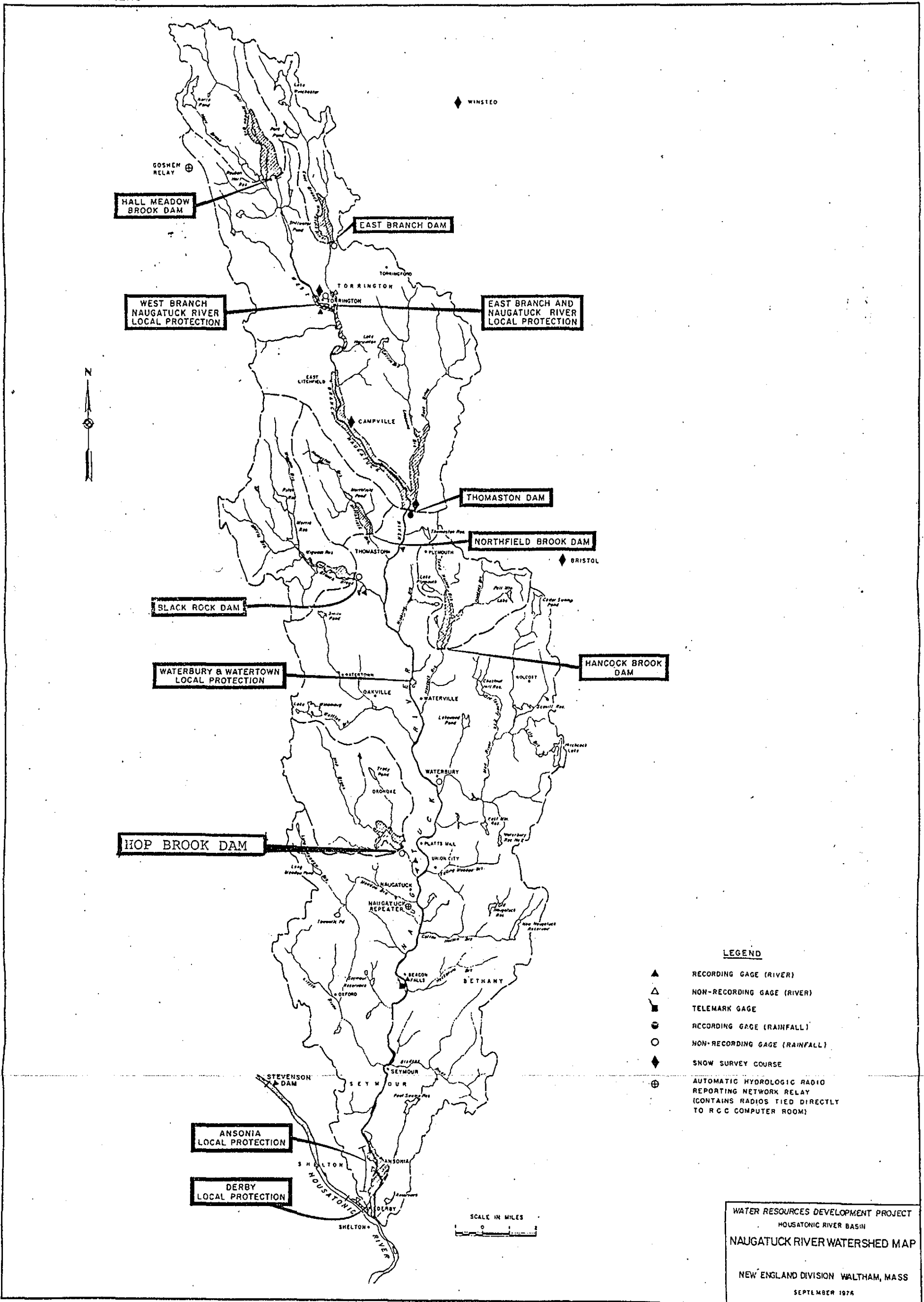
d. Recreation. No adverse impacts. The additional two feet of water will partially flood the existing beach and will require the temporary relocation of the six foot deep swimming area buoys surrounding the beach. The access to the beach as well as other recreational facilities will not be affected. It was determined that the Hop Brook pool can be raised to elevation 312.0 feet NGVD without significantly changing the recreational aspects of the project. Although the increased pool size would not restrict physical access to the lake, changes in water quality would mean more frequent closure of the beach to swimming. Algae blooms under existing conditions have been so bad as to require occasional closure of the beach and draining of the lake. Increasing the lake volume would increase the potential for nuisance blooms, possibly quite severely. Actions are being undertaken to reduce algae blooms in the lake because of the adverse effects on recreation. However, these are not likely to be enough to offset the effects of increasing the lake's size.

10. CONCLUSIONS

A drought contingency plan was developed for Hop Brook Lake that would be responsive to public needs during drought situations. This plan would permit encroachment on flood control storage to elevation 312 feet NGVD, providing an emergency water supply contingency of about 46 acre-feet (15 million gallons) over the conservation pool. Water quality problems have been identified at Hop Brook Lake to the extent that implementation is unlikely at this time. Hop Brook Lake has had past water quality problems and work has been done in the past and is continuing to try to improve the problems. If the situation improves in the future, drought contingency storage will be re-evaluated.

THIS PLAN IS, THEREFORE, NOT IMPLEMENTABLE





HOP BROOK LAKE
AREA-CAPACITY TABLE
DRAINAGE AREA = 16.4 SQUARE MILES

Stage (ft)	Elev. (msl)	Area (acres)	Capacity (ac/ft) (inches)		Stage (ft)	Elev. (msl)	Area (acres)	Capacity (ac/ft) (inches)	
0	292	0	0	0	38	330	90	933	1.07
2	294	0	0	0	40	332	102	1,125	1.29
4	296	1	1	0	42	334	112	1,339	1.54
6	298	1	2	0	44	336	121	1,572	1.81
8	300	1	4	0.01	46	338	130	1,823	2.10
10	302	2	7	0.01	48	340	139	2,092	2.40
12	304	6	15	0.02	50	342	147	2,377	2.73
14	306	14	35	0.04	52	344	154	2,678	3.08
16	308	18	67	0.08	54	346	162	2,994	3.44
18*	310	21	120	0.12	56	348	169	3,324	3.82
18	310	21	0	0	58	350	180	3,672	4.22
20	312	25	46	0.06	60	352	190	4,042	4.64
22	314	28	99	0.12	62	354	205	4,437	5.10
24	316	31	158	0.18	64	356	220	4,862	5.58
26	318	35	224	0.26	66	358	232	5,314	6.10
28	320	39	298	0.34	68	360	244	5,790	6.65
30	322	48	385	0.44	70	362	257	6,291	7.22
32	324	58	491	0.57	72	364	270	6,850	7.80
34	326	68	617	0.71					
36	328	79	764	0.88					

(Spillway Crest)

*Recreation Pool

PERTINENT DATA
HOP BROOK LAKE

LOCATION

Hop Brook, Waterbury and Naugatuck, Connecticut

DRAINAGE AREA

16.4 square miles

STORAGE USES

Flood Control, Recreation

RESERVOIR STORAGE

	Elevation msl	Stage feet	Area acres	Capacity	
				Acre- Feet	Inches on Drainage Area
Invert	292.0	0	0	0	0
Recreation Pool	310.0	18	21	120	.1
Spillway Crest	364.0	72	270	6,850 (net)	7.8 (net)
Maximum Surcharge	376.0	84	365	3,730 (net)	4.3 (net)
Top of Dam	381.0	89	---	-----	---

EMBANKMENT FEATURES

Type	Rollled earth fill, rock slope protection, impervious core
Length (ft)	520
Top Width (ft)	25
Top Elevation (ft msl)	381.0
Height (ft)	97
Volume (cy)	282,800
Dike	1 @ 400' Long, 33' High

SPILLWAY

Location	Saddle 1000' East of dam
Type	Uncontrolled, broad crested weir, chute spillway in rock
Crest Length (ft)	200
Crest Elevation (ft msl)	364.0
Surcharge (ft)	12
Design Head (ft)	12
Maximum Discharge Capacity (cfs)	23,000

OUTLET WORKS

Type	Rectangular conduit
Tunnel Inside Diameter (ft)	3' x 5'
Tunnel Length (ft)	425
Service Gate Type	Hydraulic slide
Service Gate Size	Two @ 3' x 4' high
Emergency Gate Type	None (stoplogs only)
Downstream Channel Capacity (cfs)	550+
Maximum Discharge Capacity at Spillway Crest Elevation (cfs)	600
Stilling Basin	31.5' x 14.0' wide, baffle blocks and end sill

RECREATION POOL

Length (ft)	2,200
Shoreline Length (ft)	8,660
Area (acres)	21

LAND ACQUISITION

	El. (ft msl)	Stage (ft)	Area (acres)
Fee Taking	364+300' Horiz. Strip	72	573
Easement	---	---	3
Clearing	312'	20	

MAXIMUM POOL OF RECORD

Date	29 January 1976
Stage (ft)	47.3
Percent Full	29

SPILLWAY DESIGN FLOOD

	Original Design (1964)
Peak Inflow (cfs)	20,400
Peak Outflow (cfs)	23,400*

*23,000 Spillway Discharge: 400 Conduit Discharge

UNIT RUNOFF

One Inch Runoff (acre-ft)	875
---------------------------	-----

OPERATING TIME

Open/Close all Gates	6 min. (Hydraulic Operation)
----------------------	------------------------------

PROJECT COST (thru FY75)

\$6,008,000

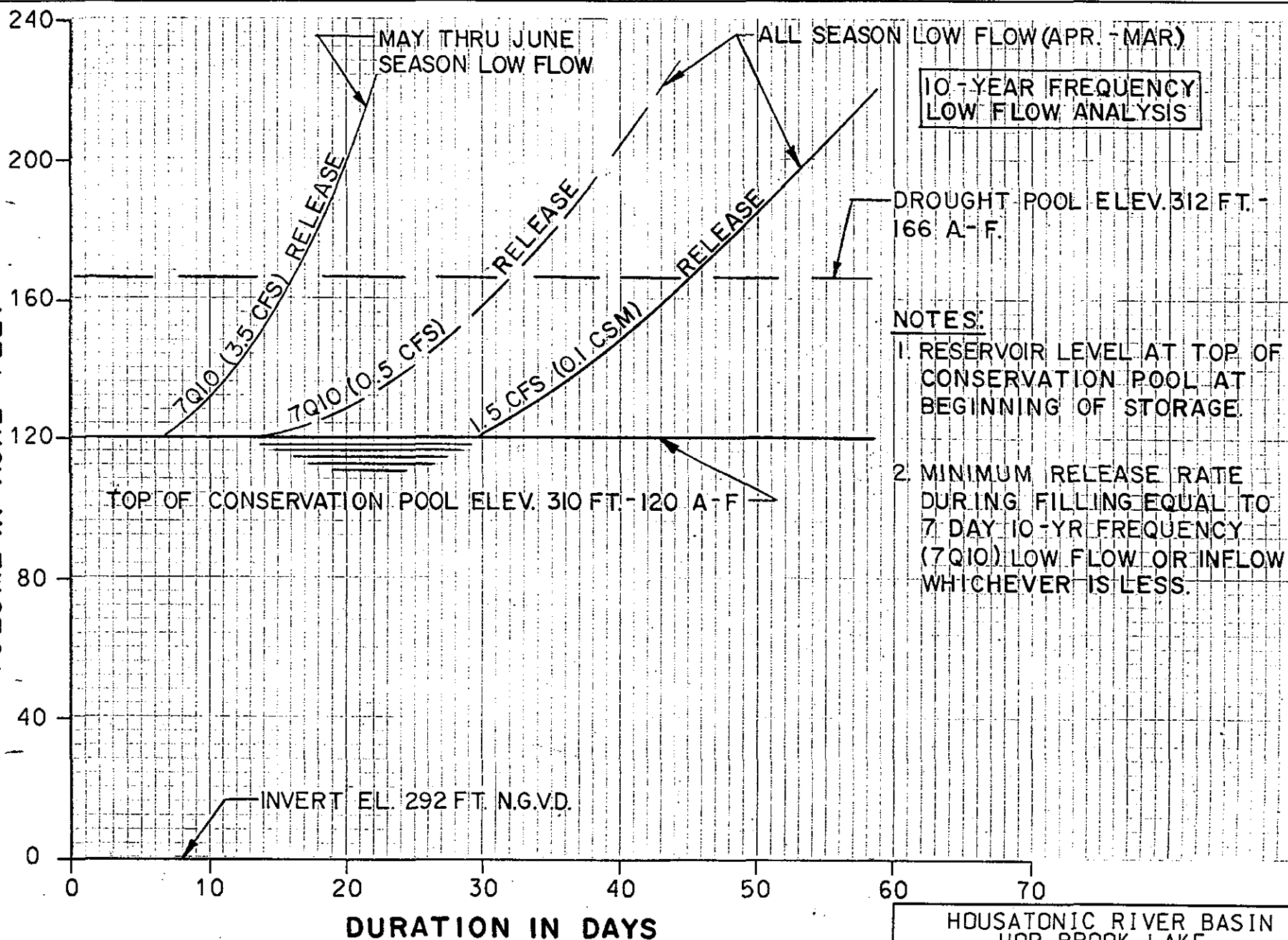
DATE OF COMPLETION

December 1968

MAINTAINED BY

New England Division, Corps of Engineers

RESERVOIR STORAGE / INFLOW
VOLUME IN ACRE- FEET



NOTES:

1. RESERVOIR LEVEL AT TOP OF CONSERVATION POOL AT BEGINNING OF STORAGE.
2. MINIMUM RELEASE RATE DURING FILLING EQUAL TO 7 DAY 10-YR FREQUENCY (7Q10) LOW FLOW OR INFLOW WHICHEVER IS LESS.

HOUSATONIC RIVER BASIN
HOP BROOK LAKE
(DA=16.4 SQ. MI.)
DROUGHT CONTINGENCY
STORAGE VS. FLOW DURATION

APPENDIX A

CLIMATOLOGIC AND HYDROLOGIC INDICATORS

APPENDIX A

DROUGHT CONTINGENCY PLAN
CLIMATOLOGIC AND HYDROLOGIC INDICATORS

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DROUGHT CONTINGENCY PLAN CLIMATOLOGIC AND HYDROLOGIC INDICATORS

1. INTRODUCTION

This appendix is presented to supplement the developed Drought Contingency Plan with climatological as well as hydrological data that are useful towards identifying and recognizing periods of dry or drought conditions. The analyses presented is not intended to predict a drought, as most drought predicting measures are not considered very accurate or promising. It is however, intended to aid in recognizing the onset of water shortage conditions in an effort to mitigate their impacts prior to severe or emergency conditions prevailing. It is most beneficial to recognize the beginning of a drought rather than to initiate action after the drought's effect become apparent.

The data presented is in the form of "guide curves" and do not serve the purpose of a single "trigger" in which emergency drought storage at Corps reservoirs would be initiated. As stated in the main text of the Drought Contingency Plan, NED's decision to store emergency water supply would be based on a combination of the guide curves as well as information received from various Federal and State agencies.

The data presented is an attempt to show regional indicators of dry or drought periods. While specific index stations were used in developing the guide curves, their use is not to be restricted to that station only. Their application is considered to represent generalized conditions in areas within the region.

Indicators such as rainfall-duration-frequency and minimum surface runoff-duration frequency were developed for various index stations within New England. Index stations selected were based on proximity to Corps drought contingency candidate reservoirs, period of record and reliability of data. The guide curves were developed and compared with historic drought data as a way to "track" current observed conditions with comparable historic conditions. Also presented is the Palmer Drought Severity Index (PDSI) classification chart with available New England historic drought index levels indicated.

2. DROUGHTS

a. General. Hydrologically, drought is defined as a prolonged period of precipitation deficiency which seriously affects riverflow as well as surface and groundwater supplies. The duration, magnitude, severity, frequency and areal extent have been identified as five common characteristics of drought. These characteristics are applicable to drought whether measured by

precipitation, streamflow, reservoir levels or by the Palmer index.

b. History. Drought history in New England before 1900 is rather limited. Periods of precipitation deficiencies were experienced, however, records of runoff deficiency are relatively non-existent. Since the establishment of streamflow gaging stations, low flow periods and drought conditions have been observed throughout the New England river basins at various times. Serious droughts occurred within New England during the periods 1924-1927; 1929-1933 and 1961-1967.

c. Drought of Record. The drought of 1961 to 1967 was the longest and most severe in the history of the New England region. This was the severest in nearly 170 years of precipitation records in Boston, Massachusetts. The 1960's drought followed a period of above normal precipitation which contributed to relaxation on the part of cities and towns during what was really a period of rapidly increasing water demand. In addition, a considerable number of water facilities failed since most had been designed to meet a repetition of the less severe drought of the 1930's.

During the period 1963 through 1966, the cumulative precipitation deficiencies (i.e. total amount below normal) varied from about 40 to 60 inches throughout New England, which is equivalent to 1 to 1.3 years of normal rainfall.

The accumulative deficiency in the average runoff for water years 1962 to 1966 varied from about 25 to 50 inches throughout New England, equivalent to about 1 to 2 years of average annual runoff.

3. CLIMATOLOGIC AND HYDROLOGIC ANALYSIS

a. General. Streamflow, reservoir levels, ground water levels, soil moisture, precipitation and the Palmer Drought Severity Index are some of the indicators used by drought managers for early detection as well as continued tracking of a drought. This analysis focused on three of these indicators: rainfall; runoff and the Palmer Index. Rainfall and runoff were selected due to the large magnitude of available historic as well as current data. The Palmer Index was selected primarily due to its wide acceptance as a reliable drought indicator. While many more parameters are used in the drought identification process, it is believed that for purposes of the Drought Contingency Plans the parameters selected and the analysis performed offer a reasonable approach to drought management at NED reservoirs.

b. Climatological Data. Rainfall frequencies for 1, 3, 6 and 12 month durations were developed for various index stations. The curves were developed using the period of record monthly rainfall data at each index station. Accumulative tabulations were made for 1, 3, 6 and 12 consecutive months, assigning Weibull plotting positions and fitting the curves through the data. Index stations

selected, with their corresponding periods of record, as well as the mean, maximum and minimum monthly rainfall, are shown in tables 1 through 3. The computed frequency curves are graphically shown on plates 1 through 3. Historic data, where available, was plotted on the 3, 6 and 12 month duration curves. The historic data was presented to allow comparison with any current data to that which occurred during historic droughts. This comparative analysis allows for a better understanding of the drought or dry period being experienced and provides for a historical perspective during drought tracking procedures.

Although the 1 and 3 month durations are presented, it is suggested that any drought emergency actions or conclusions not be based solely on the data of these short durations. In the New England region, experience has shown that low rainfall amounts for durations of 1 and 3 months do not necessarily constitute a dry or drought condition. For example: During the winter of 1988/1989 rainfall was historically low for a consecutive 3 month duration, measuring 6.5 inches at Storrs, Ct. Applying this rainfall to the 3 month curve identified the frequency to be about a 16 year drought, tracking somewhere between the historic droughts of 1924-1927 and 1980-1981. However, when the 6 month cumulative rainfall, during the same dry period, computed to be 21.5 inches, was applied to the 6 month curve, the frequency became less critical, equivalent to about a 2 year event. On an annual duration, the total 1989 rainfall amounts were considered at or above normal despite record low 3 month durations. Had drought emergency measures been implemented solely on the 3 month duration data it would have been proven to be premature or unnecessary. It is therefore recommended that although 1 and 3 month rainfall amounts should not be ignored, durations greater than 3 months should always be considered prior to any emergency drought plans being implemented.

c. Hydrologic Data. Streamflow data measured and published by the U.S. Geological Survey was used exclusively in all hydrologic analysis performed as part of this appendix. Since this analysis concerned itself with low streamflows, an attempt was made to identify and use streamflow index stations that are not regulated during periods of low flow. While many New England rivers and streams are regulated, to some extent, by mill pond dams, as well as other run of river type dams, it was assumed that any occasional regulation of low flows on the index stations selected would be considered to be minor and have minimal affect on natural low flow conditions. The mean, maximum and minimum monthly flows for four USGS gaging stations used as index stations in this report are presented in tables 4 through 7.

An annual low flow frequency analysis was made of the historical low flow data for each selected USGS gaging station. Low flows were determined for durations of 1, 3, 14, 30, 60, 90, 183 and 365 consecutive days for each climatological year (1 April

TABLE A-1

PRECIPITATION SUMMARY (INCHES)
STORRS, CONNECTICUT
ELEVATION 650 FT. NGVD
(101 Years of Record)

<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	3.65	13.79	0.64
February	3.25	7.89	0.37
March	3.94	10.65	0.15
April	3.80	10.94	0.55
May	3.76	9.21	0.33
June	3.33	12.79	0.29
July	4.15	12.15	0.78
August	4.19	14.75	0.47
September	3.84	17.00	0.45
October	3.64	8.82	0.15
November	4.00	9.24	0.47
December	3.84	9.97	0.68
ANNUAL	44.90	66.31	29.16

TABLE A-2

PRECIPITATION SUMMARY (INCHES)
AMHERST, MASSACHUSETTS
ELEVATION 150 FT. NGVD
(64 Years of Record)

<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	3.11	8.16	0.49
February	2.81	7.58	0.08
March	3.44	8.24	0.24
April	3.61	8.99	0.55
May	3.75	11.95	0.83
June	3.97	10.25	0.72
July	3.74	10.56	0.00
August	3.73	16.10	0.67
September	3.77	14.55	0.94
October	3.17	8.10	0.32
November	3.84	8.65	0.70
December	3.47	8.77	0.58
ANNUAL	42.55	60.25	29.55

TABLE A-3

PRECIPITATION SUMMARY (INCHES)
CONCORD, NEW HAMPSHIRE
ELEVATION 350 FT. NGVD
(69 Years of Record)

<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	2.69	8.09	0.40
February	2.45	7.77	0.03
March	3.12	10.36	0.55
April	3.11	6.63	0.42
May	3.10	9.52	0.60
June	3.34	10.10	0.64
July	3.38	7.57	0.96
August	3.01	6.88	0.95
September	3.16	10.68	0.41
October	2.85	8.78	0.05
November	3.73	7.59	0.50
December	4.56	10.34	0.58
ANNUAL	38.26	54.29	24.17

TABLE A-4

MONTHLY STREAM FLOW
QUINEBAUG RIVER AT JEWETT CITY, CT
DRAINAGE AREA = 713 Sq. Miles
(1919 - 1990)

<u>Month</u>	<u>Mean</u>		<u>Maximum</u>		<u>Minimum</u>	
	cfs	inches	cfs	inches	cfs	inches
January	1566	2.52	5694	9.18	219	0.35
February	1664	2.19	3919	5.16	473	0.62
March	2530	4.08	6930	11.17	1220	1.97
April	2436	3.68	5519	8.33	854	1.29
May	1534	2.47	2842	4.58	620	1.00
June	1033	1.56	4758	7.18	262	0.40
July	578	0.93	4110	6.63	138	0.22
August	498	0.80	3918	6.32	98	0.16
September	532	0.80	3502	5.28	97	0.15
October	630	1.02	3279	5.29	132	0.21
November	1066	1.61	3443	5.19	189	0.29
December	1434	2.31	4125	6.65	281	0.45
ANNUAL	1293	23.54	2015	38.24	598	11.35

TABLE A-5

MONTHLY STREAM FLOW
WEST BRANCH WESTFIELD RIVER
AT HUNTINGTON, MA
DRAINAGE AREA = 94 Sq. Miles
(1935 - 1990)

<u>Month</u>	<u>Mean</u>		<u>Maximum</u>		<u>Minimum</u>	
	cfs	inches	cfs	inches	cfs	inches
January	173	2.12	448	5.49	24	0.29
February	185	2.05	712	7.88	35	0.39
March	369	4.52	1098	13.46	112	1.37
April	503	5.97	1069	12.68	116	1.38
May	257	3.15	761	9.33	76	0.93
June	141	1.67	684	8.11	27	0.32
July	66	0.81	307	3.76	10	0.12
August	57	0.69	632	7.75	9	0.11
September	64	0.76	579	6.87	9	0.11
October	102	1.25	1041	12.76	13	0.16
November	173	2.05	544	6.45	25	0.30
December	195	2.39	664	8.14	40	0.49
ANNUAL	190	27.36	296	42.62	74	10.66

TABLE A-6

MONTHLY STREAM FLOW
SMITH RIVER NEAR BRISTOL, NH
DRAINAGE AREA = 86 Sq. Miles
(1918 - 1990)

<u>Month</u>	<u>Mean</u>		<u>Maximum</u>		<u>Minimum</u>	
	cfs	inches	cfs	inches	cfs	inches
January	99	1.33	253	3.39	19	0.25
February	99	1.20	578	7.00	21	0.25
March	254	3.41	1242	16.65	30	0.40
April	487	6.33	1077	14.00	183	2.38
May	230	3.08	504	6.76	72	0.97
June	104	1.35	353	4.59	21	0.27
July	52	0.70	387	5.19	9	0.12
August	34	0.46	168	2.25	5	0.07
September	41	0.53	457	5.94	8	0.10
October	68	0.91	267	3.58	9	0.12
November	127	1.65	379	4.93	25	0.33
December	131	1.76	393	5.27	22	0.29
ANNUAL	143	22.57	223	35.19	65	10.26

TABLE A-7

MONTHLY STREAM FLOW
WEST RIVER AT NEWFANE, VT
DRAINAGE AREA = 308 Sq. Miles
(1919 - 1990)

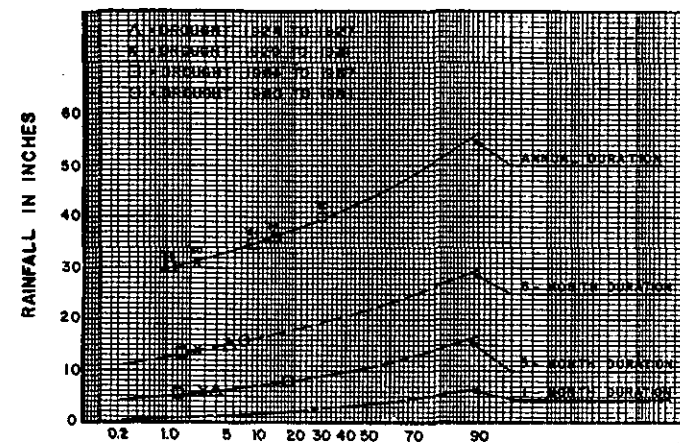
<u>Month</u>	<u>Mean</u>		<u>Maximum</u>		<u>Minimum</u>	
	cfs	inches	cfs	inches	cfs	inches
January	452	1.69	1515	5.67	95	0.36
February	444	1.50	1497	5.06	109	0.37
March	1090	4.08	3712	13.89	184	0.69
April	2199	7.92	4411	15.88	589	2.12
May	1010	3.78	2733	10.23	249	0.93
June	403	1.45	1439	5.18	64	0.23
July	205	0.77	1321	4.94	29	0.11
August	159	0.60	1539	5.76	36	0.13
September	200	0.72	1667	6.00	22	0.08
October	337	1.26	1768	6.61	33	0.12
November	567	2.04	1437	5.17	91	0.33
December	556	2.08	1578	5.91	137	0.51
ANNUAL	636	28.02	1084	47.77	272	11.98

to 31 March) using the USGS "WATSTORE" data storage and retrieval computer system. The annual low flows for each duration were fitted to a Log Pearson Type III distribution. The fitting technique involves transforming annual low flow values to logarithmic values and finding the mean, standard deviation and skew coefficient of the logarithms. The computed low flow frequency duration curves are shown graphically on plates 1 through 3. Historical data, where available, was plotted for each index station. It is noted that low flow duration curves are not shown less than a 30 day period. Within New England, low streamflow data, over a consecutive period of less than 30 days, is considered to be inconclusive when assessing drought conditions.

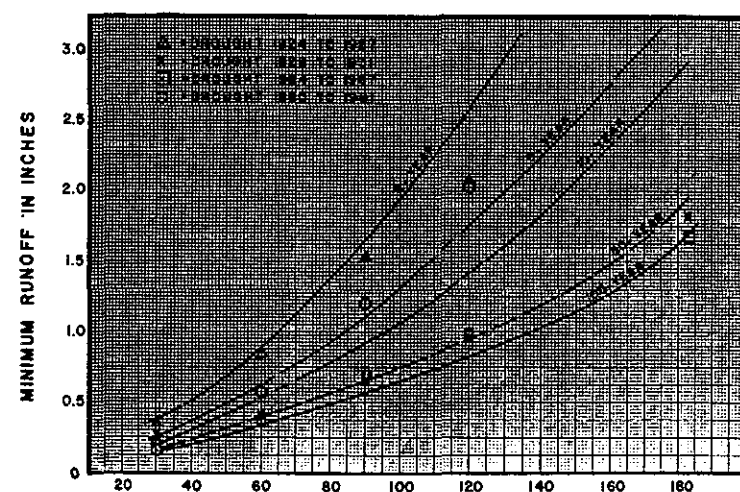
d. Palmer Drought Severity Index (PDSI). The Palmer Drought Severity Index is a widely used indicator of drought conditions. It is published in the following: "Weekly Weather and Crop Bulletin" prepared jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA); "Weekly Climate Bulletin" of the NOAA, Climate Analysis Center; and monthly "National Water Conditions" report of the U.S. Geological Survey. The National Climate Center computes the PDSI for all climate divisions in the contiguous United States.

The PDSI is a meteorological index that reflects estimates of departure of soil moisture from normal. Normal moisture conditions are derived from period of record data including monthly averages of evapotranspiration, soil water recharge, runoff and water loss from the soil. The index is standardized so that it has a consistent meaning in different climate areas and from month to month. The classification system translates the numerical value of the index to a descriptive measure of drought or wetness. The dry periods on the index are classified as extreme drought and assigned a numerical value of -4.0. The region on the PDSI graph between extreme drought and near normal conditions was subdivided into three additional drought categories: Severe (PDSI = -3.0); Moderate (PDSI = -2.0); and Mild (PDSI = -1.0). The current PDSI classification system is shown graphically on plates 1 through 3. Also shown on the PDSI graphs are the classifications assigned by others to some historic droughts data that occurred throughout New England.

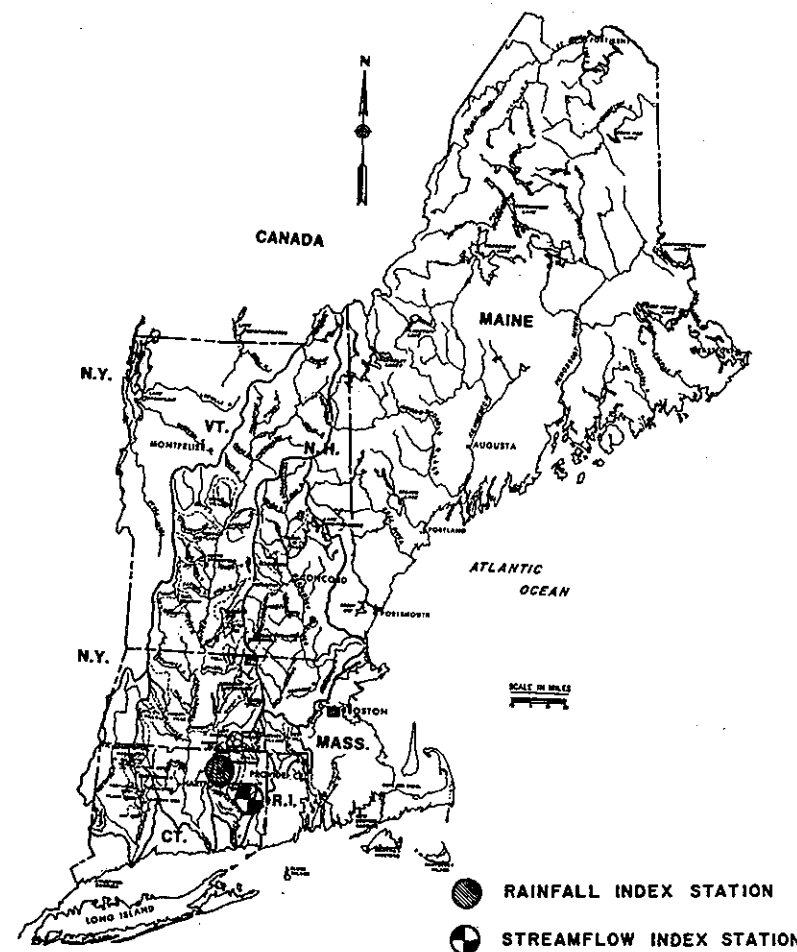
The PDSI is presented as a tool in assessing current wet or dry conditions only and should be used in conjunction with other hydrological and climatological data for effective drought management. The PDSI should not be used for drought planning or hydrologic drought forecasting.



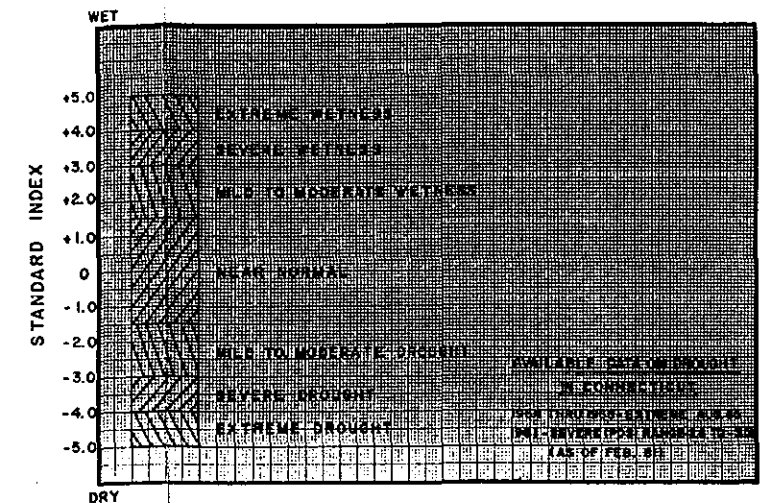
PERCENT CHANCE OF OCCURENCE IN ANY YEAR
RAINFALL DURATION CURVES
 STORRS, CONNECTICUT (EL. = 650.0 FT. N.G.V.D.)
 PERIOD OF RECORD 101 YRS.



DURATION IN DAYS
MINIMUM RUNOFF-FREQUENCY CURVES
 QUINEBAUG RIVER AT JEWETT CITY, CONNECTICUT
 D.A. = 713 SQ. MI.
 PERIOD OF RECORD 73 YRS.



RAINFALL AND STREAMFLOW LOCATION MAP



PALMER DROUGHT SEVERITY INDEX (PDSI)
 STANDARD CLASSIFICATION INDEX OF WET AND DRY PERIODS

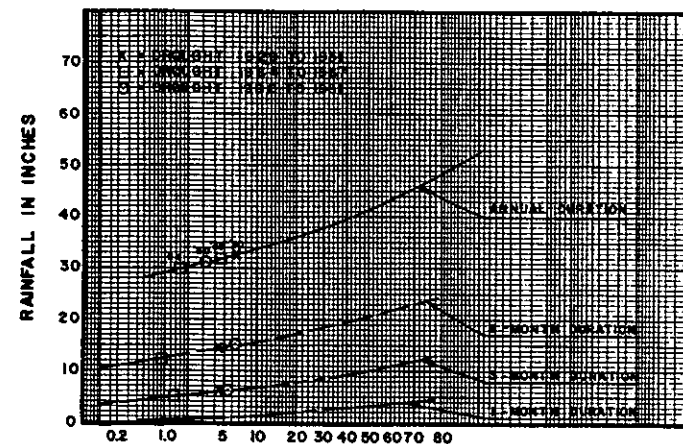
DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION
 CORPS OF ENGINEERS
 WALTHAM, MASS.

DROUGHT CONTINGENCY PLAN

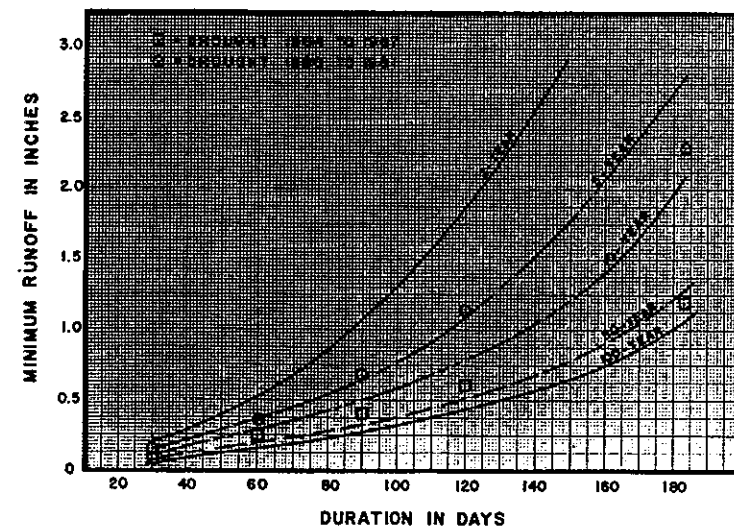
RAINFALL AND RUNOFF

GUIDE CURVES FOR

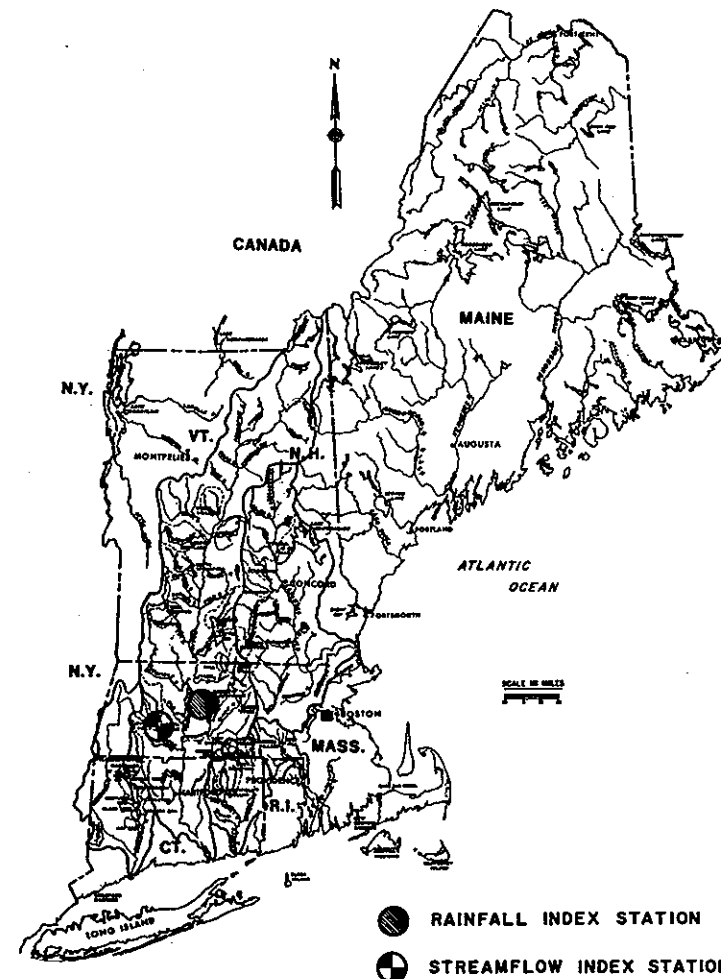
SOUTHERN NEW ENGLAND



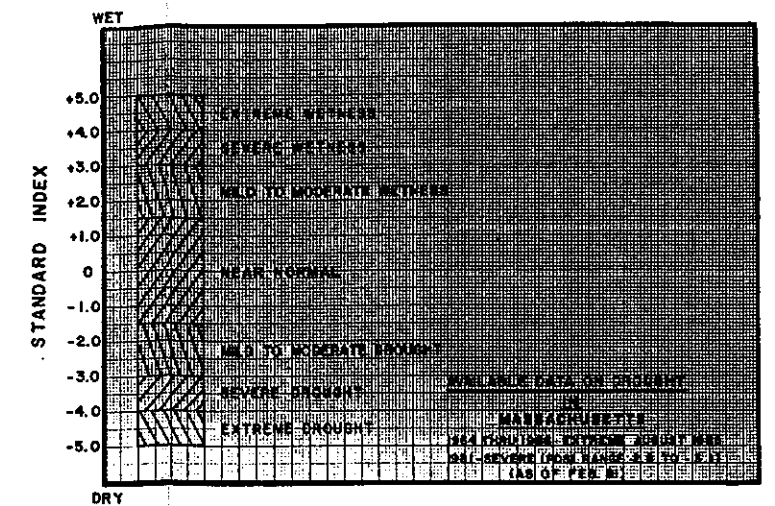
PERCENT CHANCE OF OCURENCE IN ANY GIVEN YEAR
RAINFALL DURATION CURVES
 AMHERST, MASSACHUSETTS (EL. = 150.0 FT. N.G.V.D.)
 PERIOD OF RECORD 64 YRS.



MINIMUM RUNOFF-FREQUENCY CURVES
 WEST BRANCH WESTFIELD RIVER AT
 HUNTINGTON, MASSACHUSETTS
 D.A. = 94 SQ. MI.
 PERIOD OF RECORD 54 YRS.



RAINFALL AND STREAMFLOW LOCATION MAP



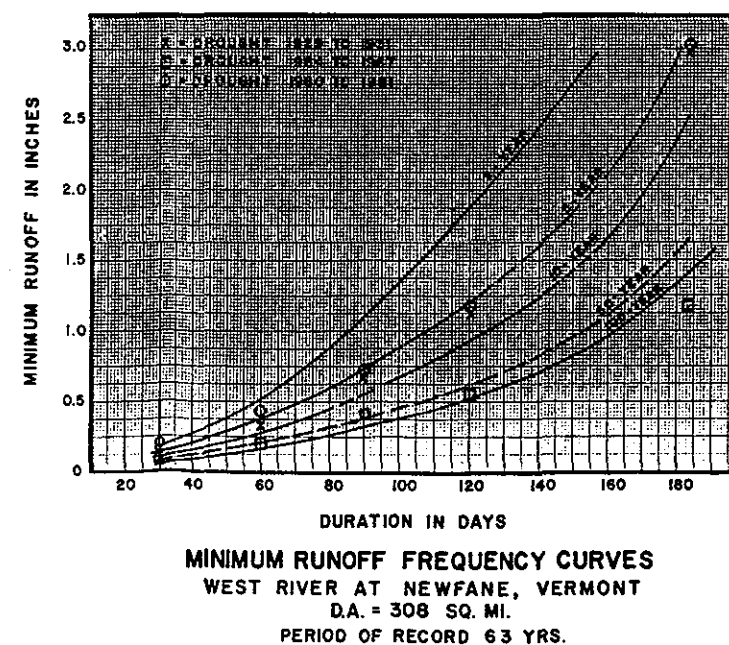
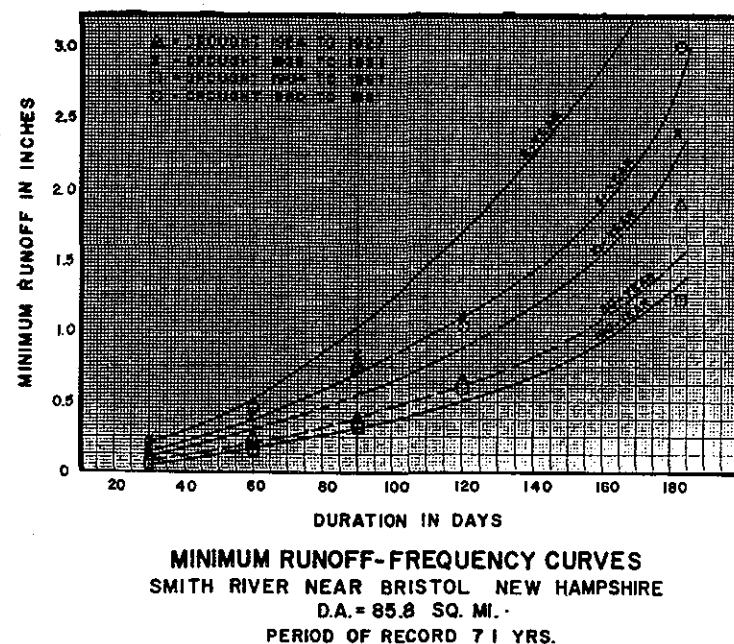
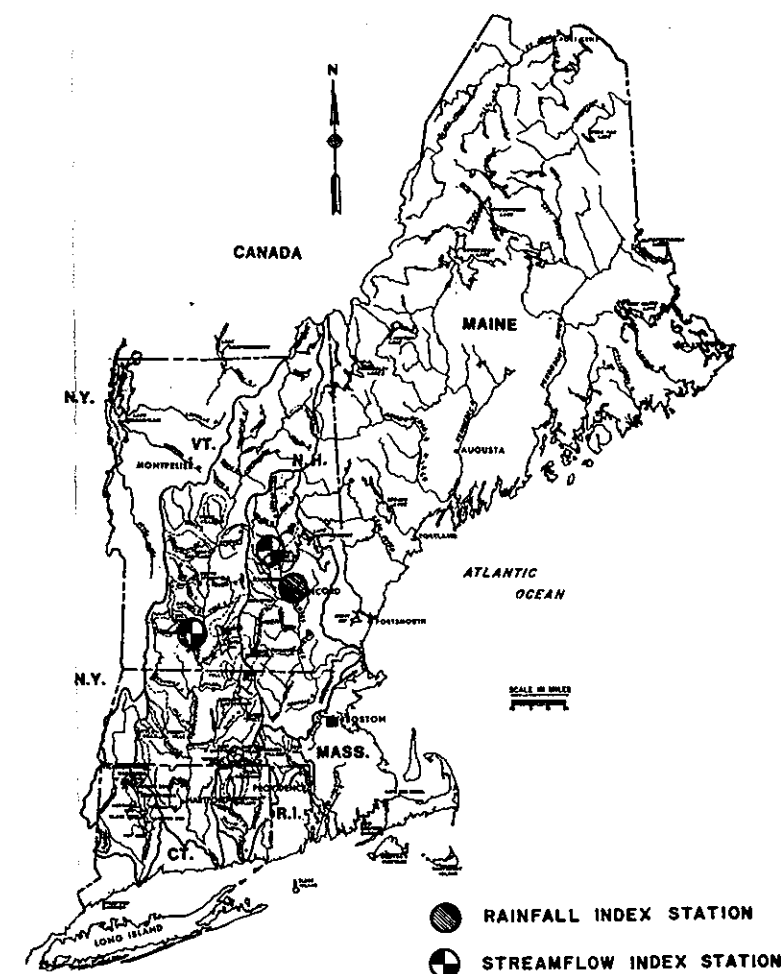
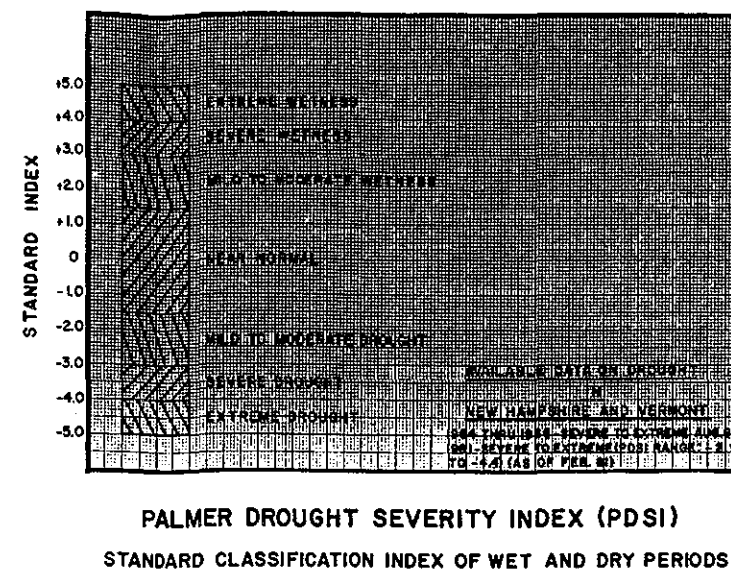
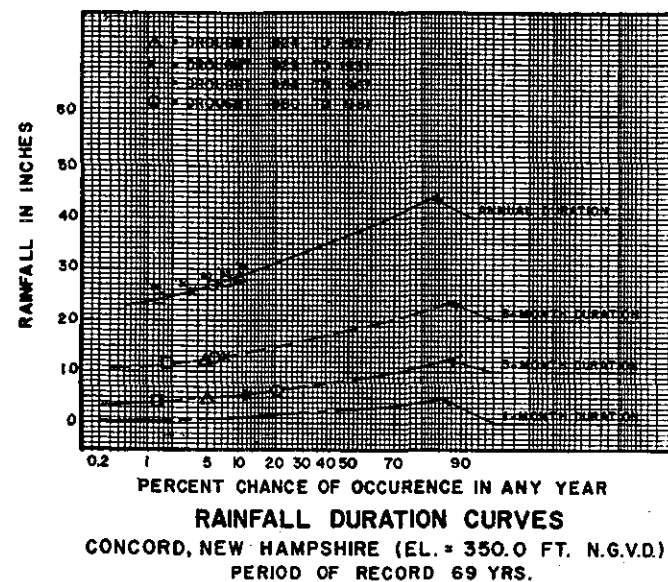
PALMER DROUGHT SEVERITY INDEX (PDSI)
 STANDARD CLASSIFICATION INDEX OF WET AND DRY PERIODS

DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION
 CORPS OF ENGINEERS
 WALTHAM, MASS.

DROUGHT CONTINGENCY PLAN

RAINFALL AND RUNOFF

GUIDE CURVES FOR
 MASSACHUSETTS AND SOUTHERN N.H.



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DROUGHT CONTINGENCY PLAN

RAINFALL AND RUNOFF

GUIDE CURVES FOR
NEW HAMPSHIRE AND VERMONT

APPENDIX B

ECONOMIC ASSESSMENT

ECONOMIC ASSESSMENT OF
DROUGHT CONTINGENCY WATER SUPPLY PRICING
at HOP BROOK LAKE RESERVOIR

APPENDIX B

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INTRODUCTION

The purpose of this report is to determine a price for drought contingency water supply at Hop Brook Lake Reservoir, Middlebury, Connecticut. The methodology was developed in accordance with ER 1105-2-100, Chapter 4, Section 7 (1990), with the exception of inclusion of updated construction cost in price determination. This methodology was developed for and used in the development of previous drought contingency plans.

METHODOLOGY

The amount to be charged for drought contingency water is determined by finding the appropriate share of joint cost attributed to drought contingency water supply, obtaining all direct separable cost that can be attributed to the provision of drought contingency water, and accounting for any benefits forgone from the existing project due to the provision of drought contingency water.

The joint cost of providing water is determined by deducting all specific cost from total operation, maintenance, replacement and major rehabilitation. The non-federal share of joint cost applied to drought contingency is determined by dividing the volume in acre-feet devoted to drought contingency water supply by the total usable storage space in acre-feet. This ratio is then multiplied by annual joint use cost to determine the non-federal share.

To the share of joint use annual cost allocated to drought contingency is added any separable cost that is due entirely to the drought contingency water supply function. Reductions in project benefits are then calculated (if any) and added to the non-federal share.

The price will be determined on an annual basis and updated for each year of the drought contingency water supply contract with the non-federal user.

WATER SUPPLY PRICE

The development of a price to be charged the non-federal user is shown in Table 1.

Joint Use Cost

Joint use cost is developed in Table 1. Joint use cost is project cost that cannot be separated by type of project benefit. This cost is obtained by deducting from total O & M cost (row 4) that cost which is specific to recreation (row 5). The result is shown in row 6. The share that is attributed to water supply is obtained by dividing acre-feet available for drought contingency water supply (row 1) by total acre-feet of available storage (row 2). This factor is shown in row 3.

The ratio of drought volume to total volume is then multiplied by joint use O & M (row 6) to determine that portion of joint cost that is to be allocated to drought contingency water supply. The result is \$11,400 and is shown in row 9.

Separable Cost

Separable cost identified as being the result of providing drought contingency water supply is the movement of buoys in the swimming area. This effort is estimated to require an additional 32 hours of labor at a cost of \$27.79 per hour (GS-9, Step One). Rounding to the nearest hundred this cost is estimated to be \$900 and is shown in row 7.

Table 1
Hop Brook Lake Reservoir
Drought Contingency Plan
Price Calculation
1993 Price Level

(1) Drought Contingency Volume (ac-ft)	46
(2) Total Volume (ac-ft)	6,850
(3) Drought Contingency Share (Row 1/Row 2)	0.007
(4) Total Annual Operations & Maintenance	\$1,870,400
(5) Recreation Annual O & M	\$ 244,300
(6) Joint O & M (Row 4- Row 5)	\$1,626,100
(7) Separable Drought Contingency Cost	\$ 900
(8) Lost Annual Recreation Value	\$ 23,600
(9) Joint O & M Apportioned to Drought Contingency	\$ 11,400
(10) Annual Drought Contingency Cost (56 days)	
(11) a. Including lost recreation value	\$ 26,249
(12) b. Excluding lost recreation value	\$ 2,649
(13) Daily Drought Contingency Cost	
(14) a. Including lost recreation value	\$ 468.73
(15) b. Excluding lost recreation value	\$ 47.30

Benefits Foregone

Benefits foregone does not refer solely to the benefits that were used to justify the project. The drought contingency pool would be established at an elevation that does not impact flood control benefits. Even though recreation benefits were not used to justify reservoir construction, recreation does currently exist at Hop Brook Lake and any impacts that a drought contingency pool would have on recreation need to be accounted for in the development of drought contingency water pricing.

Recreation opportunities available at Hop Brook Lake include swimming, boating, fishing, hiking and picnicking. Raising the pool to elevation 312 feet NGVD (two feet above the normal summer pool elevation) will have an effect on recreation. Operations Division indicates that the beach would be inundated during the months of July and August eliminating the dry beach area available to bathers. Recreation value would be lost as some bathers would not have the amenity of dry beach space. The data used to determine recreation value is displayed in Table 2.

Recreation value per visit is determined using a rating system provided in ER 1105-2-100, Section VIII-NED Benefit Evaluation Procedure: Recreation. The beach is rated under existing conditions and with a drought contingency pool. Rating criteria are shown in Table 2. The scale for conversion of points into dollars is described in Economic Guidance Memorandum 91-2. Recreation value is the product of the number of beach user days and the value per day. Recreation value declines with the drought contingency pool as the elimination of dry beach space reduces the value of using the beach. The latest visitation data provided by Operations Division indicates 369,000 visitor hours for Hop Brook Lake. Dividing by an average visit of 2.5 hours yields 147,600 user days (rounded to the nearest hundred). Multiplying this figure by the reduction in unit day value of \$0.16 yields the reduction in recreation value due to the provision of a drought pool. It is estimated that recreation value will decline by \$23,600 (rounded to the nearest hundred) annually with the drought contingency pool. Lost recreation value is shown in Table 1, row 8.

Table 2
Hop Brook Lake
Rating and Value
1993 Price Level

Hop Brook Recreation Rating		
	Existing Conditions (EL. 310)	Drought Pool (EL. 312)
1. Recreation Experience	10	10
2. Availability of Opportunity	4	4
3. Carrying Capacity	9	9
4. Accessibility	12	12
5. Environmental Quality	8	6
TOTAL	43	41
USER DAY VALE	\$4.39	\$4.23

Price Calculations

The daily price of providing for drought contingency water supply (Table 1, rows 14 and 15) is obtained by dividing water supply's share of joint O & M (row 9) by 365. To this is added separable water supply cost (row 7) and foregone recreation value (row 8). These latter two magnitudes are put on a daily basis by dividing by 56 days which is the period that drought contingency water supply would be available. The daily cost is estimated to be \$468.73 (row 14). Annual cost of \$26,249 shown in row 11 is obtained by multiplying row 14 by 56.

There are two separate prices shown in Table 1 for provision of drought contingency water. The first reflects the economic cost of providing the drought contingency pool, while the second price represents the financial cost incurred by NED only. The only anticipated difference between the economic cost and the financial cost is the inclusion of foregone recreation value in the former. The price of water should be equal to the cost of providing the water. This cost has two components - the New England Divisions direct cost of providing the water and the foregone recreation as a by-product of this process. The loss of recreation value due to the establishment of a drought pool is referred to as an externality and this loss must be included if the market price is to be economically efficient.

However, NED will charge the local water district only the Corps' direct cost of providing the drought contingency pool, or the price that reflects financial cost only. This daily price is \$47.30 and is shown in Table 1, row 15. The annual price is \$2,649 and is shown in Table 1, row 12. This pricing method will allow the non-federal sponsor to be aware of the correct trade off between water based recreation and drought contingency water. This trade off will be made at a price that reflects economic cost which includes lost recreation as well as NED's direct cost of providing the drought contingency water. The payment made to NED however, will only cover NED's direct cost.

Drought contingency water supply price should be established for a period of one year and updated in successive years based upon changes in O & M, major rehabilitation and replacement and recreation value.

APPENDIX C

WATER QUALITY EVALUATION

APPENDIX C
WATER QUALITY EVALUATION
HOP BROOK LAKE DROUGHT CONTINGENCY STUDY
WATERBURY, CONNECTICUT

1. SUMMARY

The proposed drought contingency storage at Hop Brook Lake would raise the pool 2.0 feet above its current elevation of 310.0 to 312.0 feet NGVD, and from a maximum depth of 30 to 32 feet. This increase would only occur during a declared drought period. Changes in lake water quality caused by droughts include reduced dissolved oxygen levels and increases in water temperature, iron, manganese, ammonia, phosphorus, and color. These increases could be significant and lead to a major degradation in aquatic habitat, depending on the severity of the drought. The lake would also be subject to a greater potential for the occurrence of severe algae blooms, especially since considerable algae problems already exist at this project. Increasing the pool size for drought storage, would further increase the nutrients and potential for algae problems. Additionally, increases in suspended solids, iron, and color would be expected in downstream discharges. For these reasons, drought contingency storage is not recommended at Hop Brook Lake.

2. PROJECT DESCRIPTION

a. Location. Hop Brook Lake, located in the lower Naugatuck River subbasin of the Housatonic River in Connecticut, was created in 1968 by a dam on Hop Brook, 1.3 miles above its confluence with the Naugatuck River, 3 miles southwest of Waterbury, Connecticut. The reservoir or flood encroachment area is partially within the towns of Middlebury, Waterbury, and Naugatuck, Connecticut.

b. Project Area. Hop Brook reservoir contains 616 acres. The dam and lower portion of the reservoir are within the Whittemore Glenn State Park. About three-fourths of the project area is woodland, predominantly mixed hardwood forest. The remainder of the land is mostly open land with approximately 12 acres of wetland. At normal pool, Hop Brook Lake covers a surface area of about 21 acres. The Corps maintains a beach and swimming area at the lake, which is open to the public from the week before Memorial Day to the week after Labor Day.

c. Lake Morphometry. Upon completion, Hop Brook Dam created a reservoir with a total flood control storage capacity of 6,850 acre-feet at spillway crest elevation. This storage is equivalent to 7.8 inches of runoff from the drainage area of 16.4 square miles. If filled to spillway crest, the reservoir would have a water surface area of 270 acres and a maximum depth of 72 feet. At a permanent pool elevation of 310 feet NGVD, Hop Brook Lake originally had a maximum depth of 18 feet, surface area of 21 acres, mean depth of 6 feet, and total volume of 120 acre-feet.

The lake was dredged in the fall and winter of 1979-80. This project was undertaken to: (1) straighten the original channel to reduce beach siltation which required annual maintenance, (2) improve beach aesthetics by removing mud flats apparent during periods of low flow, (3) improve fish habitat by creating deep pools and lowering the water temperature, and (4) improve flow/flushing action. It was believed that dredging might also help alleviate water quality problems such as algal blooms. With the pool elevation at 310 feet NGVD, two holes about 30 feet deep were excavated, and approximately 140 acre-feet of material was removed from the lake. This action changed the permanent pool's maximum depth to 30 feet (it remained 18 feet at the dam), volume to about 260 acre-feet, and mean depth to about 12 feet.

Additional dredging for fishery and water quality improvement was performed in 1987 (40 acre-feet), 1988 (9 acre-feet), and the winter of 1990-91 (240 acre-feet), for a total of 73 acre-feet. This material, mostly silt, was removed from shallow areas in the southwestern cove at the western end of the lake. At the same time, lake bottom countouring, boulder placement, and supplemental tire reefs were set out for fishery habitat improvements, as recommended by the Connecticut Department of Environmental Protection, Fisheries Bureau. To improve circulation and minimize areas of stagnation, the lake bottom in the southwest bay was sloped and connected to a drainage trench leading to the old river channel. These dredgings changed the permanent pool's volume to about 330 acre-feet, and the mean depth to about 16 feet.

d. Lake Parameters. At the current permanent pool elevation of 310 feet NGVD, total pool volume is 330 acre-feet and surface area is 21 acres. This pool elevation is controlled by a weir located in front of one of the project's two flood control gates. The weir gate remains open except during storage operations. The other gate generally remains closed or cracked to make small releases from the bottom of the pool, except during flood control releases.

Monthly flow rates and lake residence times for both normal and drought conditions during the critical drought storage months are listed in the following table. These flow rates are based on data collected by the U.S. Geological Survey from 1970 through 1988 at Hop Brook near the Naugatuck gaging station, located 0.8 mile downstream of the dam.

<u>Month</u>	<u>NORMAL CONDITIONS</u>		<u>DROUGHT CONDITIONS</u>	
	Mean Monthly <u>Flow</u> (cfs)	Hydraulic Residence <u>Time</u> (days)	Minimum Monthly <u>Flow</u> (cfs)	Hydraulic Residence <u>Time</u> (days)
June	28	6	1.9	88
July	17	10	0.5	340
August	11	15	0.4	420
September	15	11	0.1	1,280

e. Topography. Hop Brook originates in Watertown, Connecticut, and flows southeast to Hop Brook Lake. Average gradient of Hop Brook is about 33 feet per mile within the reservoir area. Terrain around the lake is hilly with moderate to steep relief. Above the reservoir, Hop Brook flows through a relatively narrow valley flanked by low, flat or gently rolling land in some places and high, steep-sided hills elsewhere. Within and below the reservoir, the valley widens somewhat. Elevations in the vicinity of the reservoir range from 284 feet NGVD in the streambed at the base of the dam to about 610 feet NGVD in Murray Park, Waterbury, east of the reservoir.

There are six major streams within the Hop Brook Lake watershed: Hop, Welton, Wooster, Long Swamp, Goat, and Shattuck Brooks. These streams generally originate in swampy areas, travelling through hilly terrain to their confluence with Hop Brook. Wooster and Welton Brooks join Hop Brook within the reservoir area.

f. Watershed Land Use. Land use within the Hop Brook Lake watershed is mostly residential. The eastern portion of the watershed, within the city of Waterbury, contains a number of housing developments. Route 84 intersects Route 63 within the watershed boundaries. The western portion of the watershed is in Middlebury, a suburb of Waterbury. There is extensive residential development near the lake, but the northwestern portion of the watershed is fairly undeveloped, containing some large dairy farms and many hills and swamps. There is little industrial development within the watershed.

Due to residential development, there are a number of wastewater pumping stations within the region. Two stations, in particular, have histories of failures leading to wastewater bypasses into Hop Brook Lake: Hickory Hill and Maybrook. These failures are sporadic and can cause significant temporary water quality degradation.

g. Water Quality Classification. Hop Brook and Hop Brook Lake are designated as class B surface waters by the Connecticut Department of Environmental Protection (DEP). Class B waters are suitable for bathing and other recreational purposes, agricultural uses, certain industrial processes, and cooling. Class B waters should be excellent fish and wildlife habitat, and have good aesthetic value.

Technical requirements for class B waters include a minimum dissolved oxygen concentration of 5 mg/l, no fecal coliform bacteria in excess of an arithmetic mean of 200 organisms per 100 ml sample, and no enterococcal bacteria in excess of a geometric mean of 33 per 100 ml sample, with no sample exceeding 61 organisms per 100 ml. These standards further prohibit pH, color, temperature, turbidity, solids, taste, and odor aesthetically objectionable or would impair any use assigned to this class; and also require waters to be free from pollutants in concentrations exceeding the most sensitive receiving water use.

3. EXISTING WATER QUALITY CONDITIONS

a. General. Although Hop Brook Lake's beach is heavily used, water quality in the lake is only marginally acceptable for swimming. The primary concern is high coliform bacteria levels originating from untreated discharges, wastewater pumping station overflows, malfunctioning septic systems, and runoff from dairy farms. An additional serious concern is the recurrence of nuisance algae blooms caused by excessive nutrient loads to the lake. On an average of about once a year, the swimming beach at the lake is closed because of water quality concerns created by bacteria counts or algae blooms.

The lake provides a fairly good self-sustaining warm water fish habitat. It does not have a standing cold water fish habitat; however, trout are stocked throughout the spring and summer. This put and take fishery has been only fairly successful.

Due to recurring water quality problems at Hop Brook Lake, many studies have been conducted to identify coliform and nutrient sources, and to determine the cause of excessive algal growth. Following is a synopsis of the results of

these studies including water quality sampling, algal progression, watershed nutrient mapping, lake sediment, and lake profiling.

b. Study Results. Hop Brook Lake is an eutrophic impoundment, and a variety of phytoplankton have bloomed there including diatoms, green algae, and blue-green algae. Of these organisms, blue-green algae have the heaviest blooms causing the most coloration of the water. Both green and blue-green algae have bloomed heavily enough at Hop Brook Lake to cause dissolved oxygen supersaturation and foaming in its tailwater discharge. Blue-green algae is much more of a concern at Hop Brook Lake than diatoms or green algae, since it releases compounds which may be toxic to fish and other animals. In addition, blue-green dominance in small impoundments like Hop Brook, can cause drastic fluctuations of CO₂, O₂, and pH, and increased turbidity.

Hop Brook Lake generally experiences an annual progression of algal dominance in phytoplankton from diatoms in the spring, to green algae in early summer. This progression is typical of eutrophic lakes. Often algal progression at Hop Brook goes one step further to dominance by blue-green algae, which usually begins around the first week of July. Blue-green algae has the ability to fix atmospheric nitrogen, becoming the dominant species when other algae have used up the nitrogen supply. This implies phosphorus is the limiting nutrient for algal growth at the lake, since both nitrogen and phosphorus are needed for its survival.

The principal sources of phosphorus in the watershed appear to be runoff from dairy farms, located in Hop Brook headwaters. Additional sources include lawn fertilizers and runoff from construction sites. Runoff washes fine organic material loaded with phosphorus into Hop Brook and the lake. This organic material decomposes under either aerobic or anaerobic conditions, and its phosphorus becomes available to algae. Significant phosphorus releases occur in quiescent upstream areas along Hop Brook. Abbotts Pond, in particular, has a buildup of phosphorus rich organic sediment and appears to be a major source of phosphorus to Hop Brook. Tracey's Pond also seems to contribute high phosphorus loads to Hop Brook Lake.

Phosphorus also appears to release from the sediments in Hop Brook Lake. Some decomposition and phosphorus release occur anaerobically in the two deep holes, but most occur aerobically in shallow areas of the lake. Aerobic phosphorus release is accelerated by the elevated pH, occurring when algae blooms. Therefore, once a bloom starts, it creates conditions releasing more phosphorus, intensifying the

bloom. Hot, dry summer weather and drought conditions, with little flow to flush the lake, create the best conditions for algae blooms to grow and flourish.

During lake profiling studies, phosphorus concentrations generally increased with depth, particularly at the deepest locations. Results of this study showed most DO is depleted by mid-July in the two deep holes (30 feet each) created to enhance fish habitat. Data indicated minimal mixing between these holes and overlying lake waters. Excluding the holes, average depth at the center of the lake is about 10 feet, and exhibits no well defined thermocline. Consequently, most of the lake is fairly well mixed, and dissolved oxygen and temperatures are somewhat uniform.

Dairy farms, contributing high phosphorus loads to Hop Brook, are also principal sources of coliform bacteria. Wastewater pumping stations were not shown to be substantial contributors of either phosphorus or coliform bacteria to the watershed streams except during overflows. Generally, overflows only cause relatively small temporary increases in coliform and nutrient concentrations.

4. WATER QUALITY REQUIREMENTS OF DROUGHT STORAGE

Two water quality requirements must be achieved for drought storage: (a) the waters must meet State and Federal standards for surface waters, and (b) waters must be of a quality suitable for the water supply user. Water meeting class B standards in Connecticut, is potentially usable for drinking water supply if standard treatment processes are used. Water quality requirements for industrial water supply may include treatment, depending on the process involved.

The State of Connecticut is the potential water supply user of drought storage at Hop Brook Lake. At existing pool capacity, the water is suitable for municipal (following standard treatment processes), industrial, agricultural or fire-fighting use. However, because of the lake's bacteria and algae problems, it would be a very poor source for municipal supply.

5. EFFECTS OF DROUGHT CONDITIONS ON WATER QUALITY

Drought storage is proposed at Hop Brook Lake to supply additional water to the State of Connecticut in the event of a drought emergency. Filling for drought storage would occur during the May to June timeframe. During this filling period, a minimum release rate from the dam of about 3.5 cfs (the 7-day, 10-year experienced low flow for the May to June timeframe inflow, whichever is less), would be maintained

whenever possible. The following paragraphs discuss how normal water quality could change as a result of reduced flows at the project during drought.

Droughts or long periods of low flow and warm weather can have a pronounced effect on water quality. Warm temperatures and reduced flows in streams are undesirable because stream temperatures tend to increase due to reduced depths and velocities, and dissolved oxygen levels tend to drop due to increased temperatures, reducing assimilative capacities.

Decreased inflow to Hop Brook Lake will cause hydraulic detention times to increase significantly. Detention times for drought conditions are 1 to 2 orders of magnitude greater than during normal flows (see the table in paragraph 3.c). Increases in detention times would cause the lake to become virtually stagnant.

Stagnation and warmer waters strengthen thermal stratification patterns, increasing the severity of anaerobic conditions in the lake's bottom. Sediments in areas devoid of oxygen become chemically reduced, causing iron, manganese, ammonia, and phosphorus to become soluble and diffuse into the overlying waters. Ammonia levels also tend to rise under reduced dissolved oxygen conditions due to the reduction of nitrite and nitrate. Increases in phosphorus and other nutrients fuel algae blooms, already a problem at the lake. Higher phosphorus levels would practically guarantee severe blue-green algal dominance, decreasing dissolved oxygen, increasing turbidity, and inducing major fluctuations in pH and CO₂, creating a toxic environment to fish and other wildlife. In addition, warmer waters would further enhance eutrophication of the impoundment. The more severe the drought, the greater the algae problems and water quality degradation.

6. DROUGHT STORAGE OPERATIONS

a. General. Drought contingency storage at Hop Brook Lake would increase the pool 2.0 feet above the existing conservation/recreation pool of 310.0 feet NGVD (30-foot maximum depth) to a water surface elevation of 312 feet NGVD (32-foot maximum depth) from July to November. This would increase the lake's volume by 14 percent from 330 to 376 acre-feet, and surface area by 19 percent from 21 to 25 acres.

Under the present mode of operation, releases at Hop Brook equal inflow except during flood storage periods when minimum outflow is limited to about 10 cfs. Under the drought contingency plan, filling of the drought storage pool

would likely occur in May and June, upon notification of a drought emergency. A minimum release of 2 cfs (the 7Q10 calculated for the months of May through June) or inflow, would be maintained during the filling operation. Releases should be made from the gate behind the weir, drawing warmer surface water occasionally augmented by releases from the other gate, drawing stagnant cooler water from the bottom. This type of operation should help to lessen water quality problems in the lake and downstream discharges.

b. Effects of Increased Storage on Reservoir Water Quality. The 14 percent increase in storage at Hop Brook Lake would increase the pool depth, strengthening thermal stratification, lengthen hydraulic residence times, and inundate vegetation and lands not normally covered by water for long periods. During low drought flows, most water quality changes caused by a larger pool would be minor, but degradation caused by the decay of newly inundated vegetation could significantly contribute to poorer water quality in the drought storage pool and discharge.

Increased pool volume and depth strengthen stratification patterns. At present, most of the impoundment has fairly uniform oxygen levels with depth, except for the two deep holes in which dissolved oxygen is minimal. Stronger stratification patterns could result in lower oxygen levels at the bottom of the main pool area.

Enlarging the pool will also increase mean hydraulic residence times and reduce flushing of the system, promoting warmer waters and more extreme stratification patterns. During normal flows, residence times would only increase by 1 to 2 days to about 7, 11, 17, and 13 days for June, July, August, and September, respectively. These small increases would probably not contribute much to overall water quality degradation. However, drought storage operations will take place during drought flows. Enlarging the pool during drought flows would generate more significant increases in hydraulic residence times, and, therefore, greater potential for water quality degradation. For expected drought flows in June, the lake's residence time would increase from 88 days for the existing pool to 100 days for the proposed drought storage pool. For drought flows in September, this time would increase by 180 days from 1,280 to 1,460 days.

A 2-foot increase in pool elevation at Hop Brook Lake would increase its surface area by 19 percent, inundating mostly grassed areas. Fertilizers used on the lawns would contribute high nutrient loads to the lake when inundated. Inundation of vegetated lands will also cause organic material to decay releasing nutrients and metals to the

overlying waters. This leads to increases in color and suspended sediments, and, because of additional nutrients, a greater susceptibility to algae blooms.

Raising the pool may also cause sloughing of sediments during wave action and drawdown events, increasing color, suspended sediments, nutrients, and metals levels. However, since this area is already occasionally inundated during flood control operations, especially in the early spring, sloughing may not be a severe problem. Also, newly inundated lands typically expose more insects to the water, increasing the food source for fish. In addition, the 14 percent increase in pool volume may help to accommodate additional nutrients and suspended sediments.

The composite effect of increased storage and drought (low flow) conditions will have a negative overall impact on water quality. Newly inundated acreage, low flow rates, increased residence times, and warmer waters, cause stronger stratification, lower dissolved oxygen levels, and increased algae problems.

The primary concern would be an increased potential for nuisance algae blooms, especially the blue-green type. These blooms can severely degrade water quality in an impoundment, making it hazardous to fish and wildlife. In addition, from a drinking water supply perspective, algae blooms can add offensive taste and odor to the water and interfere with treatment by clogging filters. Water quality at the lake is marginal for swimming. Increasing the pool during drought conditions, would further degrade water quality at a time of increased demand for access to beaches.

c. Effects of Drought Storage Operations on Downstream Water Quality. A minimum release of 2 cfs (7Q10 for the May to June timeframe) or inflow, whichever is less, would be maintained during the filling operation. As a natural minimum flow of that season, this release should provide downstream water quality comparable with naturally experienced conditions during drought.

Once the pool reaches the drought storage elevation of 312.0 feet NGVD, reservoir releases would be maintained equal to inflow. Any water quality degradation would then be due to effects of increased storage, and mostly to drought conditions, as previously discussed. Increases in nutrients, color, iron, temperature, and turbidity would be expected, and possibly, minor decreases in dissolved oxygen. The extent of degradation would mostly depend on the severity of the drought. During drawdown of the drought storage pool (between July and October), reservoir releases would augment

the natural inflow, causing favorable effects on temperature, DO, water depth, and velocity in the Hop Brook Lake tailwater.

Discharge should be controlled, using the gate behind the existing weir, to draw the higher quality and warmer surface waters, and keep the lake temperature down. If possible, the other flood control gate should be used to make additional releases from the bottom of the pool every so often to reduce stagnation in the lake and cool the discharge. However, lower releases would contribute more iron, color, and oxygen, demanding compounds downstream from the dam.

7. CONCLUSIONS

Drought storage is not recommended at Hop Brook Lake because of ongoing and potential water quality problems. High coliform bacteria levels and algae problems are already a major concern at the lake. These problems would be exacerbated if drought storage operations were implemented at Hop Brook Lake. Significant water quality degradation would be induced by the low flow rates and warm temperatures typical of droughts. In addition, increasing the pool size would further degrade water quality, especially during drought conditions.

Lake waters tend to stagnate and most measures of water quality worsen during droughts. Changes expected at Hop Brook Lake as a result of drought storage conditions include higher water temperatures, lower dissolved oxygen levels, and increases in phosphorus, ammonia, iron, manganese, and color. Increased phosphorus levels would fuel algae blooms, already a recurring problem at the lake. The severity of algae problems would depend on the severity of the drought, but in most cases, blue-green algae would likely dominate the lake by mid to late summer. Blue-green dominance is the most severe algal condition, and can cause drastic fluctuations in CO_2 , O_2 , and pH, increase turbidity, and create toxic conditions for fish and wildlife.

The purpose of drought storage is to provide an alternative water supply for the State of Connecticut during periods of drought. Hop Brook Lake would make a poor water supply source because of severe algae problems expected during drought storage. Algae can add offensive taste and odor to the water and interfere with treatment by clogging filters. The primary concern of drought storage, however, is increased potential for severe algae blooms, especially blue-green ones, because of their impact on recreation, and fish and wildlife.

APPENDIX D

SPONSORSHIP AND LOCAL CONTINGENCY PLANNING

P R E L I M I N A R Y D R A F T

DROUGHT EMERGENCY WATER CONTRACT
BETWEEN THE UNITED STATES OF AMERICA
AND
THE STATE OF CONNECTICUT DEPARTMENT OF HEALTH SERVICES
FOR
DROUGHT EMERGENCY WATER FROM HOP BROOK LAKE
WATERBURY, CONNECTICUT

THIS CONTRACT, entered into this _____ day of _____, 19____, by and between the UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the Contracting Officer executing this contract, and THE STATE OF CONNECTICUT DEPARTMENT OF HEALTH SERVICES, (hereinafter called the "User"); represented by
????????????.

WITNESSETH THAT:

WHEREAS, pursuant to Public Law 97-228, the Congress approved the Flood Control Act of 3 September 1954, the Government has constructed and is operating Hop Brook Lake , (hereinafter called the "Project"); and,

WHEREAS, Section 6 of the Flood Control Act of 1944 (Public Law 78-534), as amended, provides that the Secretary of the Army is authorized to make contracts with states, municipalities, private concerns, or individuals, at such prices and on such terms as he may deem reasonable, for domestic and industrial uses for drought emergency water that may be available at any reservoir under his control provided that no contracts for such water shall adversely affect the existing lawful uses of such water; and,

WHEREAS, the User desires to contract with the Government for the privilege of withdrawing drought emergency water from the Project;

NOW, THEREFORE, the parties do mutually agree as follows:

ARTICLE 1

Water Supply and Withdrawals.

a. The Government will reserve 46 acre feet of storage space in the Project in order to meet the water demands of the User. From this storage space the User shall have the privilege of withdrawing all of the water in the said storage space during the term of this contract as specified in Article 6 hereof. In the event the user needs an amount of water in excess of the aforesaid 46 acre feet the government shall determine if releases in excess of 46 acre feet are feasible in accordance with paragraph 8 of Exhibit A.

b. The User shall have the right to construct, operate and maintain installations and facilities, or to contract with third parties therefor, for the purpose of withdrawing water from the Project, subject to the approval of the Contracting Officer as to design and location of such installation and facilities. All costs associated with such installations and facilities or any modifications thereof or any future construction in connection therewith, shall be without expense to the Government.

c. The Government reserves the right to maintain at all times minimum downstream releases through the gates or spillway of the dam to meet established water requirements. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. The User recognizes that this contract provides storage space for raw water only. The Government makes no representation with respect to the quality or availability of water and assumes no responsibility therefor, or for treatment of the water. The water level of the Project will be maintained at elevations which the Government deems will best serve the authorized purposes of the Project, and this contract shall not be construed as giving the User any rights to have the water level maintained at any elevation. The User further recognizes that it is acquiring no permanent right to the use of storage in the Project.

e. The parties agree that any actions by the Government to store waters and any rights to releases of said stored water shall be governed by the provisions of a document entitled DROUGHT CONTINGENCY PLAN HOP BROOK LAKE dated September 1993 and appended hereto as Exhibit A. The said document consisting of the report and appendices A through D are hereby incorporated into this agreement by reference.

ARTICLE 2

Metering

For the purpose of maintaining an accurate record of the water released from the Project, the Government agrees to maintain records of the releases made. Such records shall include, at a minimum, the time of each release and the amount of each release.

ARTICLE 3

Federal and State Laws

a. The User shall utilize the water withdrawn from the Project in a manner consistent with Federal, State, and local laws.

b. The User furnishes, as party of the contract, an assurance (Exhibit A) that the User will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 252; 42 U.S.C. 2000d, et seq) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations. The said assurance is attached hereto and incorporated by reference.

c. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this contract shall be performed only in accordance with applicable Federal, State and local laws and regulations.

ARTICLE 4

Regulation of the Use of Water

The regulation of the use of and water rights needed for the water withdrawn or released from the storage space shall be the sole responsibility of the User and under the sole authority of the User in accord with Federal, State, and local laws and shall not be considered a part of this contract. The Government shall not be responsible for the use of water by the User, nor will it become a party to any controversies involving the water use, except as such controversies may affect the operations of the Project.

ARTICLE 5

Consideration and Payment

(a) In consideration of the right to make withdrawals from the Project for municipal and industrial water supply purposes, during periods of drought emergency as defined below the User agrees to pay the Government the sum of One Dollar (\$1) per year. This payment is due within thirty days of the effective date of this contract. The agreed fee for the 46 acre feet stored for the user is \$2,649. This payment shall be due and payable in full within thirty days of the declaration of a drought emergency by the Governor of Connecticut subsequent to the first drought of the five year contract period. The fee per acre foot for those amounts of water released in excess of 46 acre feet shall be computed by dividing 46 acre feet by the current rate for that amount of water and multiplying the result by the quantity of water in excess of 46 acre feet released to the user.

(b) The repayment amount(s) shown in Article 5(a) is based upon those factors set forth in Appendix B attached to Exhibit A.

(c) If the User shall fail to make any payment under this contract within thirty (30) days of the date due, interest thereon shall accrue at the rate as determined by the Department of Treasury; Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management") and shall compound annually from the date due until paid. This provision shall not be construed as waiving any other rights the Government may have in the event of default by the User, including but not limited to the right to terminate this contract for default.

ARTICLE 6

Duration of Contract

This contract shall become effective as of the date of the approval by the Contracting Officer, and shall continue in full force and effect under the conditions set forth herein, for a period of not to exceed 5 years from the said date of approval. Upon expiration, this contract may be extended by mutual agreement for additional periods of not to exceed 5 years each. All such contract extensions shall be subject to recalculation of reimbursement and other fees.

ARTICLE 7

Termination of Contract

a. Either party may terminate this contract and the privilege of withdrawing water upon 30 days written notice. In the event of termination under this paragraph, the Government will make pro rata refund for any balance of the contract term for which payment has been made and the User will pay all charges which have accrued through the date of the termination.

b. The Government may terminate this contract and the privilege of withdrawing water upon ninety (90) days written notice, if the User shall default in performance of any obligation of this contract. Upon such a termination, User shall continue to be liable to the Government for any monies owed and for any costs incurred by the Government as a result of the default.

c. In the event of any termination pursuant to this Article or Article 6, User shall, upon request of the Contracting Officer, promptly remove, at User's own expense, any facilities constructed on Project land for water withdrawal and restore premises around the removed facilities to a condition satisfactory to the Contracting Officer.

ARTICLE 8

Rights-of-Way

Occupancy and use of Project lands shall be in accordance with any permits, rights-of-way, or easements granted to the User by the Government.

ARTICLE 9

Release of Claims

The User shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the withdrawal or release of water from the Project made or ordered by the User, or as a result of the construction, operation or maintenance of any facilities or appurtenances owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 10

Transfer or Assignment

The User shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water or storage space of any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without the approval of the Secretary of the Army or his duly authorized representative provided that, unless contrary to public interest this restriction shall not be construed to apply to any water which may be withdrawn or obtained from the water supply storage space by the User and furnished to any third party or parties or to the rates charged therefor.

ARTICLE 11

Officials Not to Benefit

No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 12

Covenant Against Contingent Fees

The User warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage,

brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability, or in its discretion, to add to the contract price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13

Environmental Quality

During any construction, operation, and maintenance by the User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of water and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 14

Approval of Contract

This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this contract as of the day and year first above written.

APPROVED: _____

THE UNITED STATES OF AMERICA

By _____
(Contracting Officer)

DATE: _____

[Insert name of User]
By _____
[Title]

THE CONNECTICUT WATER COMPANY (CWC)^{1/}
DROUGHT CONTINGENCY PLAN

TRIGGERS

1. ALERT

A water supply alert will be initiated for a supply area whenever available water in reserve falls to a predicted supply of 150 days for that season of the year. For those systems depending on wells, estimates will be made of the available supply based on groundwater level, pumping rate and anticipated demand.

RESPONSES

A. Contact state and local agencies concerning the initiation of a water supply alert.

B. Monthly reports will be prepared for distribution to CWC management. Local and state officials, including the Department of Health Services (DOHS), and the communications media indicating the monthly trend in water reserves, the water used, the rainfall, the runoff to indicator streams and the water level in production and observation wells.

C. Customer bill messages or direct mailings (i.e., post cards) will be prepared each month for distribution to customers summarizing the drought situation. This will serve to heighten consumer awareness of the importance of their water supply. Users will be cautioned to avoid wasting water and advised on sprinkling wisely.

D. The Company will promptly investigate any deviation from normal use registered on Company production meters.

E. Review water supply emergency contingency plan and update if necessary.

2. ADVISORY

The advisory level is reached when water supply in surface and ground storage falls to 120 days' supply based on the average seasonal water demand being experienced.

A. Contact state and local agencies concerning the initiation of a water supply advisory.

B. Bimonthly water supply status reports will be prepared for in-house evaluation and for distribution to state and local officials.

^{1/} Source: The Connecticut Water Company, The Connecticut Water Company, Water Supply Plan, Naugatuck Region, Terryville System, Thomaston System, September 1992.

C. The media will be contacted to promote voluntary conservation in residential, commercial and industrial facilities to reduce demand by 10 percent from previous non-drought projected usage for the appropriate month. Mailings will be prepared for distribution to customers appealing for stringent voluntary conservation measures.

D. Internal measures will be implemented to maximize use of existing supplies and to schedule emergency equipment.

E. All supplementary water sources will be put on standby status.

3. EMERGENCY - PHASE I

The Phase I emergency level is reached when water supply in surface and ground storage falls to 90 days' supply based on the average seasonal water demand being experienced.

A. Contact state and local agencies concerning initiation of the water supply emergency Phase I plan. This is the first phase of mandatory conservation. At this level, the Company will ban all unnecessary water usage. No outside hose use will be allowed, nor are in-ground sprinkler systems to be used. A 15 percent reduction in usage from previous non-drought projections for the appropriate month will be targeted.

B. The media and all customers will be notified of the implementation of the first phase of mandatory conservation.

C. Local police will be asked to help enforce water use restrictions.

D. Weekly water supply status reports will be prepared for in-house evaluation and for distribution to state and local officials.

E. All possible supplementary water sources will be activated and prepared for use.

F. The High Priority CWC Customer List will be reviewed and revised if appropriate.

4. EMERGENCY - PHASE II

The Phase II emergency level is reached when water supply in surface and ground storage falls to 45 days' supply based on the average seasonal water demand being experienced.

A. Contact state and local agencies concerning initiation of the water supply emergency Phase II plan. Additional conservative measures including special reading of consumer meters will be put into effect and enforced by local police. Outside water use bans will continue and restrictions on nonessential commercial and industrial users will be imposed. A 20 percent reduction in usage from previous non-drought projections for the appropriate month will be targeted.

B. Twice weekly water supply status reports will be prepared for in-house evaluation and for distribution to state and local officials.

C. All supplementary water sources, upon DOHS approval, will be put into service.

D. Press releases will be developed to inform customers of the drought status and how to best cope with the situation.

E. Water company employees will issue warnings to those users exceeding a normal quota of water. Repeat violators of restrictions and warnings will have service reduced by insertion of a flow restrictor in the service line. Fines may be assessed by the civil authority.

F. A plan will be formulated in concert with state and local officials for strict rationing of water if phase III should be reached. The needs of high priority CWC customers, homes, commerce and fire protection will be established and prioritized. A predetermined water storage minimum will be held for fire protection. Plans will be made for emergency service of drinking and cooking water by tanker to any areas where normal water service must be terminated.

G. Alternate means of obtaining additional water supplies will be investigated.

5. EMERGENCY - PHASE III

Water reserves fall to less than 14 days' supply.

A. The Company, in cooperation with appropriate state and town officials, will initiate the prearranged drought hazard rationing plan described in item F, Phase II. The details of the rationing program will depend upon the nature of the individual water system but will provide for the bare essentials of life sustenance for as long as possible. The plan will consider needs of high priority CWC customers, homes, commerce and fire protection. Non essential commercial and industrial use would be cut off in accordance with the established priorities. A preset storage minimum would be held for extinguishing fires, the amount needed depending upon the nature of the structures in the service area. Arrangements will be instituted for emergency service of drinking and cooking water by tanker to any areas where normal water service must be cut off. Mandatory rationing of water will be strictly enforced by local police and company personnel.

It is important to have this type of civil defense response to natural disaster in place in each community to cover all types of emergencies that may result from wind storm, flood, fire, earthquake or large scale accident such as severe contamination of air, land or water by dangerous chemicals. A tank truck spill, or a rupture or leak of an in-ground gasoline, oil or chemical storage tank could suddenly incapacitate a reservoir or a groundwater aquifer, despite the best planning to forestall such an occurrence. The object of planning allowable uses of well and reservoir watersheds is to reduce the likelihood of such an event.